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Jay Gould on Rapid Transit. OUR daily contemporary, the New York *Tribune*, has been interviewing that philanthropic friend of the public, Mr. Jay Gould, regarding rapid transit in New York. Mr. Gould is apparently convinced that it is his duty to inform his fellow citizens of the very serious risks and enormous engineering difficulties to be met with in the construction of underground roads. Such an addition to the facilities for the traveling public he regards, to be sure, as not specially inimical to the elevated roads, but as most undesirable, and, financially, as a sort of rat hole into which indefinite money can be dropped without producing results. More than all, Mr. Gould evidently distrusts electric traction, and, carefully led on by a reporter, he was tempted into expressing the opinion that it would take a long time and large bank account to develop the electric motor. Apparently, he has not heard of the great success that has been achieved abroad in this very kind of service; but no one ever talks so enthusiastically as on a topic of which he knows nothing, and the opinions of the wily and eminent capitalist will doubtless be quoted right and left as based on undoubted electrical authority.

An Interesting Machine. ON another page we give an account of a very ingenious separately excited dynamo that is shortly to be placed on the market. It is a type of machine that has not previously been worked on any extensive scale, although it has some rather marked advantages. Strictly speaking the Winkler dynamo is not altogether separately excited, for the magnetizing circuit happens to be furnished from a separate winding on the armature. But as a result of the arrangement the dynamo possesses two rather interesting qualities. In the first place it lends itself very readily to governing for compensating varying speed, and in the second place it is free from the self-inductive kick of the magnetizing coils that sometimes gives very unpleasant shocks to those who undertake to handle the wires without due protection. The former attribute is the more valuable of the two, and results from the fact that a pair of light brushes controlling the magnetizing circuit can be twisted around nearly 90 degrees without perceptible sparking and with a very small quantity of friction, so that not only can the dynamo be utilized very easily for operation in connection with water-wheels, but it would make a rather neat and effective arc machine. Several other devices of the same inventor are described in our article, and altogether the group of electrical appliances is one worth looking at.

The Accumulator in Court. IN addition to the important incandescent lamp suit that is now before the public, it must be remembered that storage battery litigation has been in progress during the last week before Judge Coxe, who has already become familiar through dire experience with the traps for the unwary that lie in storage battery litigation. The present suit is one between the Electric Accumulator Company and the Brush company—in other words a test of the validity of the Brush patents, and during its progress attention has been given to a number of important points that were left untouched in the Brush-Julien litigation of last year. As is well known that suit was practically settled before the final decision was reached, while in the present case the claims of both parties have been pushed forward very sharply and without forgetting a possible advantage on either side. Mr. Brush's patent is a strong one, and he came off victor in the interferences within the Patent Office; but there are several suggestive questions, notably one regarding the Italian patent to Brush, that will be, presumably, decided on their merits in the opinion to be rendered by Judge Coxe shortly. The history of the storage battery has been, on the whole, a tale of woe almost from the beginning, and it is only recently that things have taken on a somewhat brighter aspect. It is to be hoped that the suit now under judgment will clear the air a little, and leave the rights of the respective parties sufficiently well defined to encourage the development of the art.

The Poor Man's Light. AT a recent meeting of the Western Gas Association one of its members, who by his own statement had never invested in an electric light plant, congratulated himself and comforted his fellow-gasometers by proving to their mutual satisfaction that the incandescent electric light is forever barred from becoming a successful competitor of gas. This statement has been so often repeated by those most ignorant of the subject that we feel some embarrassment in commenting on it at the present day. Nevertheless, one of the accompanying statements is worth a little discussion. The incandescent lamp is in the aforesaid paper stigmatized as "the rich man's light." Now, as touching the general question of economy the electric light is to-day in a very large number of places furnished at one cent per lamp hour, the equivalent of just about $2 per thousand feet for gas. As regards the economy of the matter, this statement ought to be quite sufficient. If the incandescent light is, as was stated, 64 per cent. more costly to produce than an equivalent amount of gas, the gas companies are, by their own confession, carrying on a business so extortionate that in the interests of civilization it ought to be regulated. The electric light to-day can and does compete with gas at ordinary prices in the most successful manner. As regards the allegation that it is the rich man's light, nothing can be more utterly false. We had the pleasure a year or two ago of inspecting an electric light plant in a small western town, looking over every foot of wire on the line and every lamp installed. So far from being the rich man's light, the service was extended into every quarter of the town, and lamps were installed in small cobbler shops and cheap lodging-houses; in stables, cellars and outhouses. It was to be found everywhere where a good and convenient light would be wanted. While the incandescent lamp may be a convenience to the rich man, at the present price it is available for every one who would ever think of using gas. Among those who are too poor to use either illuminant, kerosene oil and candles are still employed, and it will be a long time before either electricity or gas can supersede these for such a class of consumers. But perhaps the most striking case of economy from the use of electricity comes in large isolated plants such as are found in hundreds of office buildings and factories all over the country. It has been shown that with an installation of considerable size the cost per lamp installed per day, including every item of expenditure, can be reduced to less than 1¼ cents per lamp per day, and this even when a separate plant is operated by steam power. Where water is available the conditions for electric lighting are even more favorable.

The Electric Light Convention. THE recent meeting of the Executive Committee of the National Electric Light Association at Montreal was a rousing success and promises the greatest convention in the history of the Association, and the finest electrical exhibits that have ever been gathered together on such an occasion. In the first place, the time, somewhat later than usual, and the place are both auspicious. For Montreal, the metropolis of Canada, is the centre of immense business interests, and, furthermore, our Canadian cousins have made preparations to welcome their visitors with open arms, and no more cordial and enthusiastic reception could have been wished than that which was given to the committee as a small sample of what might be expected by the association. We do not always realize the amount of push and drive that there really is across the Canadian border, and the meeting will probably be somewhat of a surprise to both parties. The most prominent citizens of Montreal are active in furthering the success of the convention, and they and the executive committee are to be congratulated for the arrangements that have been made. In another column we give some account of what is proposed, and to sum it up it will be seen that the intention of the hospitable Canadians is to paint the town red in honor of their visitors. An immense hall has been provided for exhibits, and something like 300 h. p. will be available for motive purposes. In spite of the enormous room that will be ready for the exhibition something like three-fourths of it has already been applied for informally, and the task of the executive committee will not be to fill the hall, but to so apportion the space as to give everybody a chance. The 7th of September is the opening day, and the exhibition will be continued from the 7th until the 16th, inclusive, giving ample time for the business meetings as well as the entertainments which have been so cordially offered. Altogether it promises to be the most successful convention in the history of the association, and to exhibit the warmest welcome that has ever been extended to a visiting organization.

Rapid Telegraphy. A RECENT paper by Mr. Gisborne, of Ottawa, electrician to the Dominion, given at the recent meeting of the Royal Society of Canada in Montreal, contains some very interesting statements about rapid telegraphy. Mr. Gisborne stated by way of data that 3,000 words per minute had been transmitted by a roundabout line of copper wire 355 miles long between New York and Washington, while 800 had been reached over the 1,000-mile line between New York and Chicago, and he expressed the opinion that the telegraph of the future would be largely conducted by means of such rapid transmitters as were used in these experiments. It may be interesting to note that the automatic machine telegraph employed is the invention of Mr. F. Anderson, of Connecticut, and that it is of the perforated paper class of instruments, registering each message by ink marks showing the ordinary Morse signals. From this the speaker went on to show that a message of 100 words could be transmitted over 1,000 miles of line for 25 cents, and yet allow a large profit for the telegraph companies. Such a statement may appear a little surprising at first sight, but it must be remembered that a pair of lines working at the highest speed mentioned is the equivalent of something like 40 complete quadruplex systems, each requiring its own wire, and worked by the ordinary key. The decrease in expense of line and maintenance accomplished by the substitution of these transmitters for the ordinary instruments would be something enormous, to say nothing of the far smaller number of operators and instruments required. The perforation, of course, is done by machines constructed on the principle of the typewriter, and can be done at a considerably greater rate of speed than that at which messages are now sent. Mr. Gisborne also stated from intimate knowledge of the statistics of telegraphy in this country and elsewhere, that the volume of business is sufficient to insure the success of a system worked as described. It is, perhaps, too soon to express a definite opinion as to the general applicability of the rapid transmitter, for the Morse instrument worked in the old way is likely to hold its own for the great bulk of local messages; but as regards the success of through lines so operated there can be even now little doubt. Perhaps it is worth mentioning that the long distance telephone lines can be utilized most efficiently in this way, and when the agreement between the telephone and telegraph companies now in force expires by limitation, as it will shortly, it is not impossible that we may be treated to some exhibitions of rapid telegraphy that will be rather surprising to those who have not made themselves familiar with the turn affairs are taking. The statements just mentioned are not the sanguine predictions of an enthusiastic inventor, but the judicial opinions of a veteran telegrapher who knows what he is talking about, and has had abundant practical experience.

Latest Foreign Electrical News.

(By cable from our own correspondent.)

LONDON, June 15, 1891.—The London overhead wires bill passed the House of Lords last week after a considerable amount of time lost in unwinding the legislative red tape. Also the bill reviving the Worms-Bale patent for tanning by electricity, which was recently invalidated on points of law.

The fleet of electric launches on the Thames has received an accession recently in the shape of two new boats.

The Mutual Telephone Company has recently opened an xchange in Manchester which has been a pronounced success, and is about to extend its system to Leeds and other towns in Yorkshire.

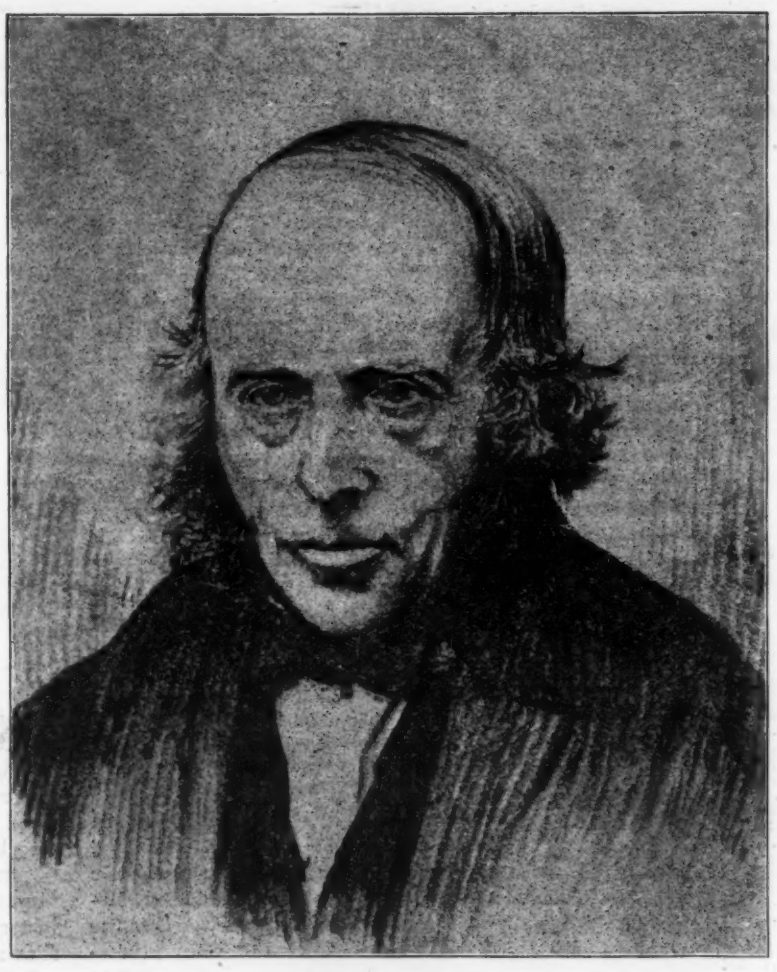
The death is announced of Dr. William Edward Steavenson, well known as a student of electro-medical science. Dr. Steavenson was the grand-nephew of Dr. Robert Steavenson, of Newcastle-on-Tyne, who wrote on medical electricity as early as 1778. He was born in Suffolk in 1850, was educated at Downing College, Cambridge, and received his degree of doctor of medicine in 1884. He was casualty physician at St. Bartholomew's Hospital in 1882, and there took charge of the electrical work, getting a large amount of electrical experience. He was physician to the Grosvenor Hospital for Women and Children and to the Alexandra Hospital for Children. He was the author of a well-known treatise entitled "Electricity and its Manner of Working in the Treatment of Disease," and numerous articles in the scientific journals.

ELECTRICAL WORLD PORTRAITS.—XXVI.

ROBERT DAVIDSON.

Some time ago we published an account of the first electrical railway, at least the first that was anything more than a mere workshop model, and we now have the pleasure of presenting to our readers the portrait of Mr. Robert Davidson, its inventor, probably the oldest living electrician, and certainly the Nestor of the art of electrical traction.

Robert Davidson was born April 18, 1804, in Aberdeen, Scotland, where he is living to-day. His father was a prosperous tradesman there, and young Davidson had the advantage of an education that for those days was more than usually extended. After some instruction in several private schools he entered, along with his elder brotner, as a student in the Faculty of Arts at Marishas College. He was fortunately enabled to study here for a longer time than usual on account of the assistance he gave one of the professors in providing a model steam engine for demonstration purposes. During his study there he was specially taken up with the study of chemistry and mechanics. On leaving college he was apprenticed to his father, but his natural bent for mechanics and his training made the work irksome for him, and shortly afterward he set up an establishment for the manufacture of yeast on a large scale, where his chemical knowledge came into play and enabled him to secure more than usual success. From this line of work he branched out into that of manufacturing chemist, and for nearly half a century manufactured chemicals for use in woolen mills and dye-houses.



ROBERT DAVIDSON.

All through this active work he was devoted to the study of chemistry and to mechanics. Among other things he set up a shop as a file maker. One of his mechanical hobbies, too, was astronomy, and about 1828 he manufactured a large telescope, which he set up in his grounds, where it remained for many years. His chief interest, however, centered on electrical appliances. From his student days he studied the subject earnestly, and after long trials he completed the large electric motor "Galvani," in 1837. It was not until two years later that it was first presented to public notice, at which time Mr. Davidson carried it over a large part of Great Britain, and gave (as reference to our previous article will show) a large number of successful exhibitions. It reached a speed of as high as five or six miles an hour, and finally was maliciously destroyed, probably by the steam engineers, who feared that their occupation would be gone. The great cost of chemicals, and the suspicion with which this newfangled device was regarded by the railway companies, checked its further development, and after its destruction Mr. Davidson did not build a new machine. Along with the locomotive was exhibited a small boat-shaped model of a flying machine, the success of which is not recorded. A few years later, when photography became known, Mr. Davidson took up the subject, and was, perhaps, one of the earliest of the race of amateur photographers.

In spite of his weight of years Mr. Davidson is even now a bright old man, and full of reminiscences of his long and interesting career. He certainly was one of the pioneers of applied electricity, working contemporaneously with Thomas Davenport, the Vermont blacksmith, and on a much larger scale. He has lived to see the dream of his youth more than realized in the everyday work of his old age, and now in the evening of a long and useful life he can look back over the half century that is gone, and, as the oldest electrician, appreciate perhaps even more than others the success of those who have followed him.

Tests of a Mechanical Vacuum Pump.

About a year ago the announcement was made that a mechanical vacuum pump had been devised for exhausting incandescent lamps, and that it would give equally good results with the Geissler and Sprengel pumps in general use. A little later the pump was fully described in THE ELECTRICAL WORLD, and it will be remembered that the principle of its construction was at once novel and effective, consisting in forming a vacuum jacket around the principal working cylinders by the use of subsidiary cylinders which might themselves be used for the preliminary stages of exhaustion. The effect of this device is to reduce the difference in pressure between the sides of the pump piston, and consequently to diminish almost to a vacuum point the leakage that has heretofore interfered with the action of mechanical vacuum pumps.

A short time ago we had the pleasure of seeing the improved pump in operation at the works of the Beacon Vacuum Pump Company in Boston, and its performance there was sufficient to set at rest any doubts that might have existed as to its ability to compete with mercury pumps in the production of perfect vacua. The three-cylinder pump illustrated in THE ELECTRICAL WORLD has been considerably improved in the past year, and the one tested was an eight-cylinder machine of much larger capacity. On the day of inspection the pump had been at work on various tasks of exhaustion, some of them not at all conducive to its perfect action, such, for example, as exhausting vessels that contained moisture. After the machine was put in working order for the lamps, a gang of nine 32 c. p. bulbs was placed on one of the pipes leading to the pump. With the present arrangement over 100 lamps can be exhausted at once, and a little extension of the leading pipes would enable numerous other groups to be added. Two gauges were fitted to the apparatus, one of them a McLeod of the usual construction, the other a test bulb in which the mercury could be allowed to run at will and removed without breaking the connections. The nine lamps were put in position and the pump started; four minutes later the test bulb showed a remaining bubble .35 inch in diameter; at the expiration of 10 minutes this was reduced to .21, and five minutes later to .14. At the expiration of 21 minutes from the time of starting the pump the test bulb showed a bubble of .11 inch, and the lamps were then flashed on the pump for a brief period. Thirty-five minutes after the pump was started the lamps were sealed off, the test bulb then showing a bubble only .07 inch in diameter. One of the bulbs was taken to the laboratory and broken under mercury, and in spite of the larger size of the 32 c. p. bulb seven one-hundredths was the extreme diameter of the bubble. A few minutes later the bubble in the test bulb had been reduced to three one-hundredths of an inch, but as it was desired to rush the lamps through so that they could be tested for candle-power and capped immediately, they were removed at the stage mentioned. The eight bulbs put on the photometer showed very slight variations in voltage, and under the induction coil test compared favorably with the results of mercury pump exhaustion. Two of these lamps, intended for 98 and 99½ volts respectively, have been burning, off and on, for a couple of weeks, six or eight volts over the rated figures, and have performed admirably; they will be subjected to a more extensive test later.

It should be said that the final vacuum had an apparent actual value as given by the McLeod gauge of about $\frac{1}{300000}$ and is well up to the results of mercury exhaustion. At another test a little later still more extensive exhaustion was tried. In the first instance twelve 16 c. p. lamps, a single group, were put on the pump; 10 minutes exhaustion showed a test bubble .14 inch in diameter, and seven minutes later, when the lamps were sealed off, this had been reduced to .07. This is rather quicker work than in the trial just mentioned, but the twelve 16 c. p. bulbs had considerably less capacity than the nine 32 c. p. ones previously exhausted. Next 24 lamps were put on the pump in two groups; 10 minutes reduced the residual bubble to .17 inch in diameter, and 20 minutes to nine. With 48 lamps 25 minutes sufficed to bring the entire group to a stage of exhaustion corresponding to a residual bubble one-tenth of an inch in diameter, and when, as a final experiment, 96 lamps were put upon the pump, only 40 minutes was necessary to bring the exhaustion down to the desired point of showing a bubble about nine one-hundredths of an inch in diameter. On neither of these occasions was any special effort made to fit the pump for doing its finest work. The experiments were rather casual than deliberate in their character, and give a very good idea of what this really extraordinary pump is capable of accomplishing. The strokes are slow and the cylinders large, so that although the work is done with great rapidity a very small amount of power is required to operate the machine, only a fraction of a horse power.

A new pump of even greater capacity than either of the previous ones is just being placed in position, and is expected to give at least as good results in exhaustion and in a very much shorter time. The pump is certainly capable of carrying on the exhaustion far enough to leave the residual bubble not more than three one-hundredths of an inch in diameter, which will be recognized by lamp makers as a very satisfactory degree of vacuum, considerably better than is generally attained. With the new pump in position the number of lamps exhausted simultaneously can be largely increased, or with the ordinary groups the time of exhaustion can be greatly reduced. The great rapidity with which the pump works also produces a good effect in allowing a much briefer period of flashing on the pump than is usually given incandescent lamps, the vapor produced by flashing being drawn off at once. In one of the experiments the current was turned on the lamps after they had been on the pump but 10 minutes. Such a reduction of time from the several hours usually required with mercury pumps is no small factor in incandescent lamp manufacture, to say nothing of the decreased time required in the process of flashing. Altogether the performance of this mechanical pump is extraordinary, both in the great rapidity of its work and the completeness with which the beautiful vacuum jacket device has overcome the difficulties of leakage that had rendered futile all previous efforts at obtaining high vacua by the use of air pumps other than mercurial.

Professor Ewing's Theory of Magnetism.

Professor Ewing recently delivered an interesting discourse at the Royal Institution on the "Molecular Process in Magnetic Induction." After succinctly summing up the theories of Poisson and Weber, he alluded to his own remarkable extension of the molecular hypothesis without, however, connecting his own name with this valuable addition to our knowledge. The curious, and, in the light of Ewing's theory, instructive behavior of magnetic needles under the influence of magnetizing forces was illustrated in a most admirable manner by means of the lantern. Owing to the inability to employ a large number of small needles, however, the stage immediately preceding complete instability was scarcely as well marked as one would wish. The phenomena of recalescence and decalescence were exhibited in a striking manner by employing a thin steel wire some 12 feet long and heating it up by means of the electric current. Attached to the end of the wire was a long and conspicuous lever. As the wire heated this traveled round until the point of decalescence was reached, when the motion was momentarily arrested. The reverse phenomenon of decalescence on cooling down was still more marked by this device. In conclusion, Prof. Ewing referred to the beautiful experimental corroboration of his theory which had come to hand that morning from America, and the hysteresis curves obtained by Mr. Hoopes with his bar of needles were thrown on the screen

The Winkler Dynamo and Motor.

It is not often that a dynamo appears before the public possessing any unusual features of construction, or embodying in an essential way departures from the usual lines of practice followed in electrical designing. It must be confessed, however, that Mr. C. F. Winkler's ingenious dynamo possesses several novel features, some of them of considerable merit. The cuts give a good idea of the character of these innovations. As at present built, the machine is a constant potential, compound wound, separately excited dynamo. As Figs. 1 and 2 readily show, it is of the Manchester type, with, as usual, wrought-iron cores and cast-iron pole pieces and frame. It is in the armature that we find the real novelty; this is a combination of a Gramme ring, which furnishes the exciting circuit, and a Siemens winding, that furnishes the working circuit. The armature possesses two commutators, one for each of these windings. Fig. 3 shows the internal construction of the armature. Between the two end plates and insulated from them are fitted a series of iron conductors dropping below the periphery of the end plates nearly to the shaft, and connected across their tops to form a Gramme winding, as shown in the figure. Before the upper connecting bars are put in position, however, insulating material is placed over the frame formed by the armature conductors, and iron wire is then spun upon the armature as in the original Gramme construction until a solid mass is built up flush with the end plates. Then the connecting bars are put in position, the insulation placed between them and the core finished up. We then have a Gramme ring with a comparatively small number of segments formed of iron conductors. The requisite amount of magnetic material being furnished by the iron wire laid on, after the armature is finished to this point it is wound just as any other drum armature would be wound, a single layer of copper being used. There are, then, two distinct circuits upon the armature, one a Gramme winding capable of delivering the exciting current for the field magnets the other an ordinary Siemens winding of sufficient power to give the desired voltage. The field coils are compound wound, the principal magnetizing circuit being connected to the Gramme winding, as just mentioned, and requiring in a 300-light machine something like 300 watts, supplied at about 30 volts. A compound winding of the ordinary sort is supplied outside the coils of the separately excited circuit. As at present constructed the armature when ready for the reception of the winding is perfectly smooth, but one of the modifications that can easily be introduced is to channel the iron conductors of the Gramme ring so as to form a toothed drum armature to receive the copper windings. One of the objects of employing this general form of construction was to avoid the severe self-inductive shock that can be received from the powerful shunt coils of an ordinary machine. The self-induction of the dynamo is not high enough to give a severe shock, even when the working brushes are lifted with the hands; in fact there is hardly any perceptible shock at all; and while one does not customarily break the circuit of a dynamo on himself there is a degree of consolation to be derived from the knowledge that the only source of injury is that proportionate to the direct voltage of the machine. The brushes on the exciting circuit are capable of being shifted through a full quarter revolution without perceptible sparking, and the working voltage of the machine can thus be varied from practically zero to its full amount by the rotation of the exciting brushes. This dispenses with any external regulator and at the same time furnishes a very convenient means of automatic governing.

It frequently happens that it is desired to install an incandescent dynamo where only water power is attainable; especially where other machinery is driven from the same wheel, it becomes very difficult so to regulate the speed that the voltage will remain constant. Mr. Winkler places for such service a centrifugal governor to operate the brushes of the exciting circuit, a task requiring comparatively little power, so that any variation in the speed of the water-wheel is immediately compensated by an increased exciting current. It goes without saying that an electromagnetic device to accomplish the same end will fit the machine for constant current working. The compounding of the standard machine is very good indeed, giving practically no variation from light load to full load. These dynamos are now built by the Troy Electric Dynamo Company, but arrangements are nearly completed for going into the manufacture on a considerable scale with much increased facilities.

Aside from the dynamo Mr. Winkler is the inventor of several other additions to the list of electrical appliances. One of these is the street car motor, well shown in Fig. 4. A single motor is employed per car, a 20-h. p. machine of the consequent pole type fitted with the Gramme armature. This is arranged to run freely until the power is applied to the car by a friction clutch, that in practice operates very successfully in putting on the load gently and smoothly. The natural result of this contrivance is to reduce the tremendous initial rush of current ordinarily found, and to utilize to a great extent the momentum of the armature in overcoming the static friction of the car. Both axles are driven by this single motor, the power being transmitted from the directly driven axle to the other by means of a pair of wire ropes running over pulleys of the peculiar construction shown in the cut. These were invented by Mr. Winkler a short time ago and give a grip on the driving rope that renders slipping quite out of the question. In actual trial the motor runs very smoothly, the load is taken up very gradually, and the motor runs without excessive noise or perceptible sparking. The momentum of the armature is sufficient to start the car from rest, even when the current is cut off before throwing on the friction clutch. The armature speed is low enough to permit the use of a single reduction gear, and the mechanical construction employed is such as to secure a good, durable, serviceable machine.

Aside from the motor and dynamo Mr. Winkler is the inventor of a rather interesting storage battery. It is of the usual lead type, but the grids are so constructed as to expose a large surface of active material without danger of buckling and give an amount of mechanical stiffness that is something prodigious. During charging and discharging the active material does not press severely on any part of the grid, and the latter, from its form of construction, is so stiff that it is next to impossible to bend it with the hands, or to force it out of shape in any way that would cause ill results to the battery. Besides this the exciting fluid is somewhat gelatinous in character, so that even when the plates are taken out of the cell a considerable current can be obtained from them, and if the cell were overturned there would not be enough spilling of the fluid to interfere with its action or surroundings. The exceedingly stiff grid and large surface of active material enable an enormous current to be taken from the battery in case of need. Its efficiency, electromotive force, and other characteristics are presumably very closely allied to those of other lead batteries, but the strength of the cell and its power to resist buckling under a very large discharge are unusual. A number of other minor devices have been brought out by Mr. Winkler in addition to those we have mentioned, but these three, the dynamo, motor and storage battery, appear to be very solid and business-like affairs. They are soon to be placed on the market on a large scale, and will doubtless give a good account of themselves. Under test the dynamo has given an efficiency of somewhere nearly 90 per cent.; in other words it is, as might be expected from the general construction, a reasonably effective commercial machine, and also possesses the merits of giving no appreciable shock aside from that which might naturally be expected from the equivalent continuous voltage, and permitting very simple regulation in cases where the speed of the prime mover is variable.

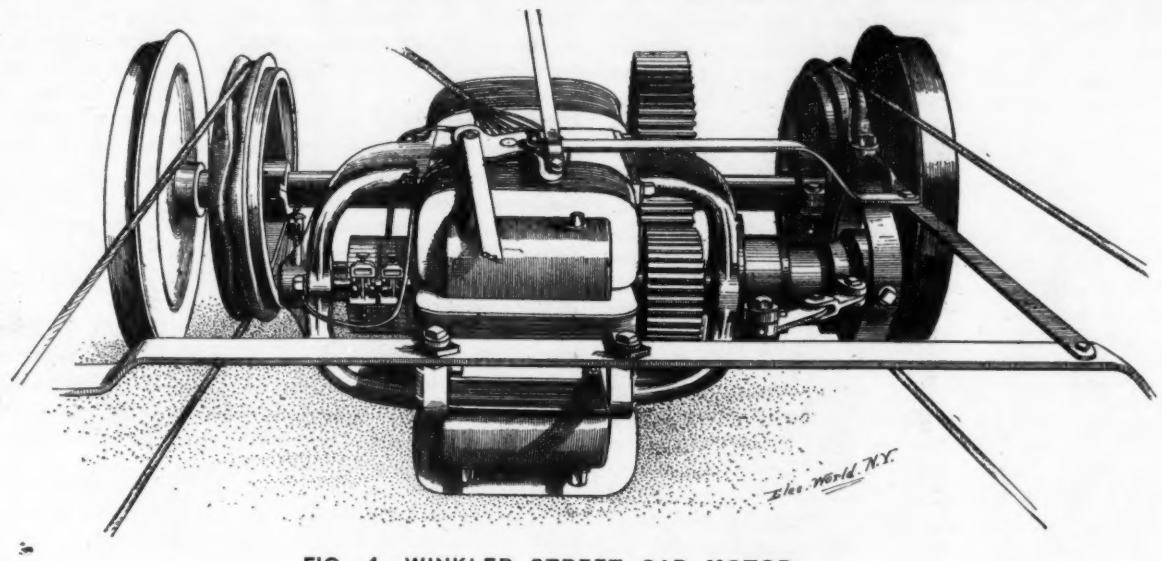


FIG. 4.—WINKLER STREET CAR MOTOR.

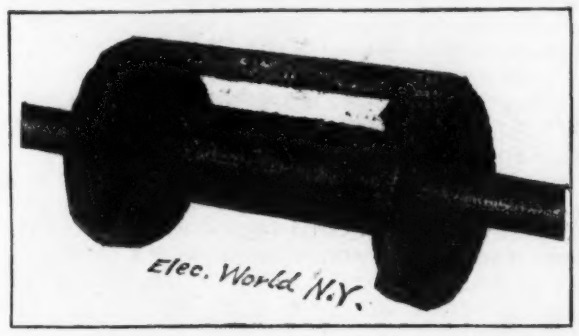


FIG. 3.—INTERNAL CONSTRUCTION OF ARMATURE.

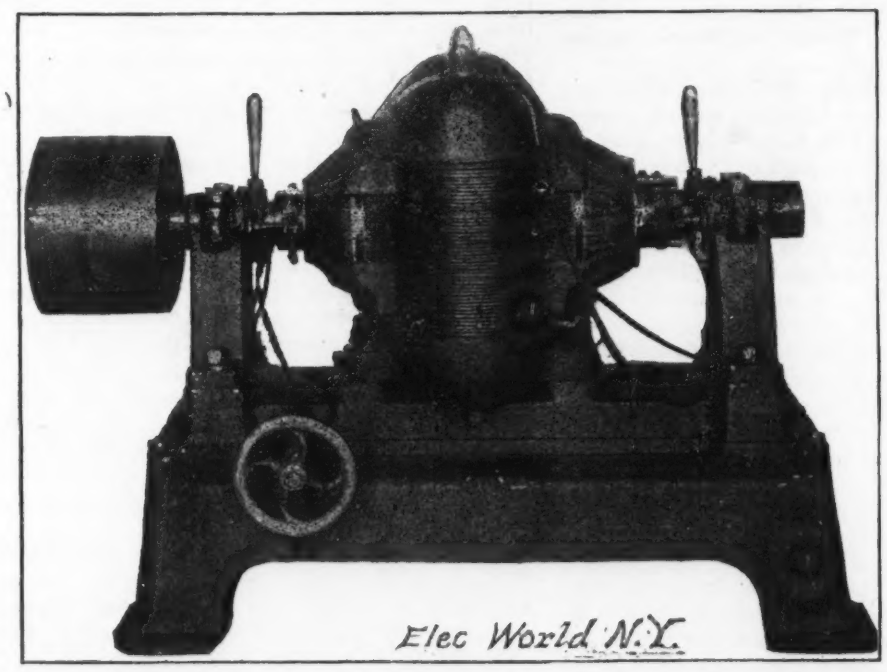


FIG. 1.—WINKLER DYNAMO.

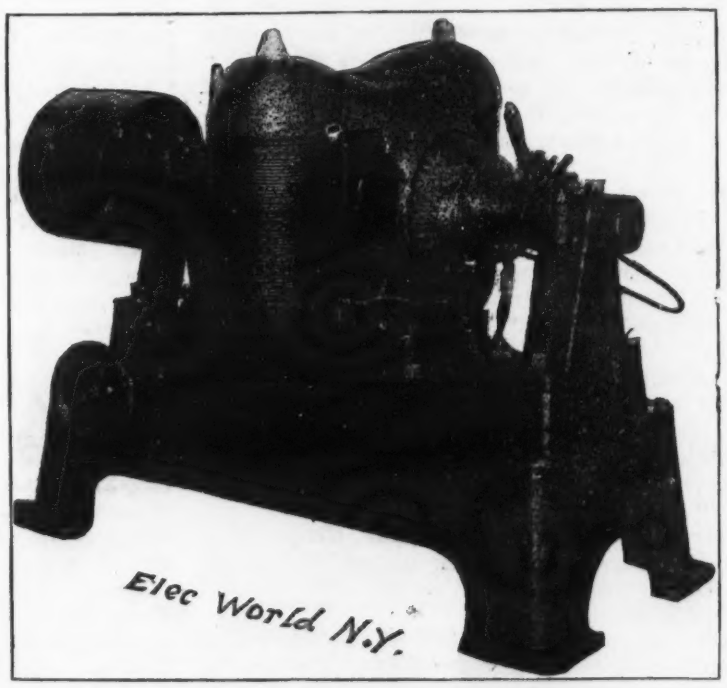


FIG. 2.—WINKLER DYNAMO.

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Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1657.——Schott (Gaspar)—P. Gasparis Schotti—who was sent to teach natural philosophy and mathematics at Palermo, Sicily, is the author of several very curious works on physics, of which the most important alone will here be noted.

"Magiæ Universalis Naturæ et Artis, etc.," appeared at Herbipoli in 1657, 1658, 1659. In the first book of the fourth volume (or part) he indicates, according to Kircher, whom he had met while in Rome, the means of conveying one's thoughts at a distance by the loadstone, and he alludes to the speaking head constructed by Albertus Magnus, while, in the third and fourth books of the same volume, he gives a long treatise on the loadstone as well as an account of numerous experiments made with it.

"De Arte Mechanica, etc." ("Mechanicæ, etc."), Herbipoli, 1657-1658, contains, in second part, class I., p. 314, the first published notice of Von Guericke's experiments.

"Physica Curiosa sive Mirabilia Naturæ, etc.," Herbipoli, 1662 (which may justly be considered a continuation of the "Magia Universalis") treats in the eleventh book of St. Elmo's fire, thunder and meteors in general.

"Technica Curiosa sive Mirabilia Naturæ, etc.," Herbipoli, 1664, alludes, in the two first books, to the experiments made by Von Guericke and by Boyle, and gives the contents of eight letters written him by the first named.

"Schola Steganographica, etc.," Norimbergæ, 1665, gives, at pages 258–264, a description of the dial telegraph of Daniell Schwenter.

"Jocoseriorum Naturæ et Artis, etc.," published about 1666, alludes to the "Thaumaturgus Mathematicus" of Gaspar Ens, published at Cologne, 1651, as well as to the "Deliciœ Physico-Mathematicæ" of Daniell Schwenter and Geo. Philippi Harsdorffer (Senator of Nuremberg), to "La Récréation Mathématique" of Jean Leurechon, and to the works of Cardan, Mizault, Aldrovande and others.

See "Notice Raisonnée des Ouvrages de Gaspar Schott," par Mr. L'Abbé Mxxx de St. Léger de Soissons, Paris, 1785, pp. 6, 31, 32, 37, 44, 70; Muirhead's translation of Arago's Eloge de James Watt, London, 1839, p. 51.

A. D. 1675.——Boyle (Robert). Irish natural philosopher and chemist, seventh son of Richard Boyle, Earl of Cork, and one of the first members of what he calls the "Invisible" or "Philosophical" College, which has since become the Royal Society, gives, in his "Philosophical Works," the result of his many experiments upon magnetism and electricity.

John Evelyn says of him: "It must be confess'd that he had a marvailous sagacity in finding out many usefull and noble experiments. Never did stubborn matter come under his inquisition but he extorted a confession of all that lay in her most intimate recesses; and what he discover'd he as faithfully register'd, and frankly communicated. . . . "

Professor Tyndall remarks ("Lecture," Feb. 4, 1875): "The tendency to physical theory showed itself in Boyle. He imagined that the electrified body threw out a glutinous or unctuous effluvium, which laid hold of small bodies, and, in its return to the source from which it emanated, carried them along with it." (Priestley, "History of Electricity," 1775, p. 7; Boyle, "Essays of the . . . Effluviums," London, 1673: (Subtilty) pp. 38-42, 52, 53, (Efficacy) pp. 18, 19, 32, 33; Boyle, "An Essay . . . of Gems," London, 1672, pp. 108–112).

A few of his many characteristic remarks and observations are, however, best given in his own words, as extracted from the "Philosphical Works" above alluded to:

"The invention of the mariner's needle, which giveth the direction, is no less benefit for navigation than the invention of the sails, which give the motion." (London, 1738, vol. I., p. 62.)

"I, with a certain body (rough diamond), not bigger than a pea, but very vigorously attractive, moved a steel needle, freely poised, about three minutes after I had left off rubbing it" (vol. I., p. 508). Speaking elsewhere of his experiments with diamonds, he says: "But when I came to apply it (the loadstone) to one more, which look't somewhat duller than almost any of the rest, I found that it had in it particles enough of an iron nature to make it a magnetical body and observed without surprise that not only it would suffer it self to be taken up by the strongest pole of the loadstone, but when the pole was offer'd within a convenient distance it would readily leap through the air to fasten it self to it."

"I removed a piece of amber in the sunbeams till they had made it moderately hot and then found it would attract those light bodies it would not stir before." (Vol. I., p. 400, and vol. III., p. 52.)

"Whether from such experiments one may argue that it is but, as it were, by accident that amber attracts another body, and not this the amber; and whether these ought to make us question, if *electrics may*, with so much propriety, as has been generally supposed, *be said to attract*, are doubts, that my design does not oblige me to examine." (Vol. IV., p. 350.)

See John Evelyn's "Diary," Letter to Mr. Wotton, March 30, 1696; Libe's "Histoire Phil. du Progrès de la Physique," Paris, 1810; Boyle's "Mechanical Origine or Production of Electricity," 1675; Secondat's "Histoire d'Electricité" (Observations physiques), 1750, p. 141; Whewell, "Hist. of Ind. Sciences," 1859, vol. I., pp. 395, 396. Priestley's "History of Electricity," 1775, pp. 5–8. Mr. Reael "Observ. a. d. Magnectsteen," 1651, alluded to at note, page 486, vol. I., of Van Swinden's 1784 "Recueil, etc."

Consult also Boyle's "New Exper. Physico-Mechanical, etc.," in which the 16th Exp. is "concerning the operation of the loadstone"; Boyle's "A Continuation of New Exp., etc.," in which the 31st Exp. is "about the attractive virtue of the loadstone in an exhausted receiver," and in which are "Notes, etc., about the atmospheres of consistent bodies, etc.," as well as "Observations about the exciting of the electricity of bodies," and concerning the electrical emanations and effluviums. Boyle is also the author of "Tracts Containing Some Suspicions Concerning Some Occult Qualities of the Air; with an Appendix Touching Celestial Magnets, etc."

See, likewise, Boyle, "Phil. Works," London, 1744, vol. III., pp. 65, 67 and 70, also pages 647, etc., giving his "Experiments and Notes about the Mechanical Origin or Production of Electricity," and, for full accounts of the Royal Society, alluded to above, see the histories written by Thomas Sprat (1667), by Thomas Birch (1756), by Thomas Thomson (1812), and by Chas. Richard Weld (1847–1848).

A. D. 1675.——Picard (Jean), eminent astronomer, who succeeded Gassendi (A. D. 1632) as professor of astronomy at the Collège de France, is the first to observe electric light *in vacuo*. According to Tyndall ("Lectures on Electricity") it was while carrying a barometer from the Observatory to the Porte Saint-Michel in Paris that he noticed light in the vacuous portion. Sebastion and Cassini observed it afterward in other barometers. (See Tyndall's "Lecture V." for Priestley's description of the electric light *in vacuo*.)

It was this same scientist who had already given; in his "Mesure de la Terre," 1671, article IV., the description of the measurement of a degree of latitude made with instruments of his own manufacture. (See "Cosmos," 1859, pp. 23, 24.)

A. D. 1675.——Newton (Sir Isaac), prominent English mathematician and natural philosopher, of whom Macaulay says that "in no other mind have the demonstrative faculty and the inductive faculty coexisted in such supreme excellence and perfect harmony," communicates to the Royal Society his discovery that excited glass will attract any light bodies even to the surface opposite to that upon which it has been rubbed. This was successfully demonstrated by the Society, Jan. 31, 1676.

He improved the electric machine by substituting a glass globe for the globe of sulphur made use of by both Von Guericke and Boyle, the rubbers in every case being the hands of the operator.

He appears to have somewhat anticipated Franklin's great discovery, judging by the following extract from a letter he addressed, Dec. 15, 1716, to the Rev. Dr. Law, in Suffolk: "I have been much amused by ye singular phenomena resulting from bringing of a needle into contact with a piece of amber or resin fricated on silke clothe—ye flame putteth me in mind of sheet lightning on a small (how very small) scale. But I shall in my epistles abjure philosophy, whereof, when I come down to Sakly, I'll give you enow."

During the years 1686 and 1687 Newton composed his "Principia," "a work which will be memorable not only in the annals of one science or of one country, but which will form an epoch in the history of the world." This was published at Halley's expense. As Brewster says (1686, chap XII.): "It is to Halley alone that science owes this debt of gratitude. It was he who tracked Newton to his college, who drew from him his great discoveries, and who generously gave them to the world."

In the 23d proposition of the second book, fifth section, Newton says: "The virtue of the magnet is contracted by the interposition of an iron plate and is almost terminated at it, for bodies further off are not so much attracted by the magnet as by the iron plate." And in book III., prop. VI., he thus expresses himself: "The magnetic attraction is not as the matter attracted; some bodies are attracted more by the magnet, others less; most bodies not at all. The power of magnetism in one and the same body may be increased and diminished, and is sometimes far stronger for the quantity of matter than the power of gravity; and in receding from the magnet decreases, not in the duplicate, but almost in the triplicate proportion of the distance, as nearly as I could judge from some rude observations."

Newton is said to have carried in his ring a magnet weighing but three grains, which could raise 746 grains, or 250 times its own weight. This magnet naturally excited much admiration, but is surpassed in power by that formerly belonging to Sir John Leslie, and now in the Physical Collection at Edinburgh, weighing three and one-half grains, and having a carrying power of 1,560 grains.

See Brewster's "Life of Sir I. Newton," pp. 307, 308; Harris, "Magnetism," vol. III., p. 11; Ninth "Britannica," vol. XV., p. 274; Whewell, "Hist. of the Ind. Sciences," 1859, vol. II., p. 213 (note); also the interesting note at foot of page 683 of the Fourth Dissertation in the "Encyclopedia Britannica." See also Muspratt's Chemistry, vol. II., p. 255; the English *Chemical News* for November, 1867, and January, 1868, reproducing Sir David Brewster's letters to the London *Athenæum* and London *Times*, likewise Dr. Crompton's paper read before the Manchester Literary and Philosophical Society in October, 1866.

A. D. 1676.——Haward, master of several ships, and a man of good credit (*Phil. Trans*, vol. X., No. 127, p. 647, of July 16, 1676), states that "being on board of the ship Abemarle, July 24, 1641, . . . in latitude of Bermuda . . . after a terrible clap of thunder . . . it was found that the compass card was turned around, the N. and S. points having changed positions and, though Mr. Grofton brought with his finger the flower-de-lys to point directly N., it would immediately, as soon as at liberty, return to this new unusual posture, and upon examination he found every compass (three) in the ship of the same humor; which . . . he could impute to nothing else but the operation of the lightning or thunder mentioned." The above is also alluded to at page 33 of vol. III. of Boyle's "Phil. Works," London, 1738, with this addition: "One of the compasses, pointing West, was brought to New England, where, the glass being broke and the air gaining entrance, it lost its virtue. But one of the others is in that country possess'd by Mr. Encrease Mather, the North point of the needle remaining South to this day."

A. D. 1677—At page 14 of an exceedingly curious publication entitled "A Rich Cabinet with a Variety of Inventions, etc.," written by J. W. (*i. e.*, John White, of London), who calls himself "a lover of artificial conclusions," will be found an article on "Divers rare, conceited motions performed by a magnet or loadstone."

A. D. 1678.——Redi (Francesco), well-known Italian scientist, physician to the Grand Duke Ferdinand II., publishes his "Experimenta circa res diversas Naturales," wherein he is first to communicate the fact that the shock of the raia torpedo can be communicated to the fisherman through the line and rod connecting him with the fish.

See Leithead, "Electricity," chap. XII.; the Firenze, 1671 ed. of his "Esperienze, etc.," pp. 47–54; *Sci. Am. Supp.*, No. 457, pp. 7,300–7,302.

A. D. 1679.——Maxwell (William)—Guillelmo Maxvello—native of Scotland, author of "Medicina Magnetica," offers to prove to various medical faculties that, with certain magnetic means at his disposal, he could cure any of the diseases abandoned by them as incurable. (Blavatsky, "Isis," vol. I., p. 215.)

See J. H. Van Swinden, "Recueil de Mémoires, etc."; La Haye, 1784, vol. II., p. 367.

A. D. 1683.——Halley (Edmund), L.L. D., who became English astronomer royal, makes known his theory of four magnetic poles and of the periodical movement of the magnetic line without declination. He states that the earth's magnetism is caused by four poles of attraction, two of them being in each hemisphere near each pole of the earth. By the word *pole* he means a point where the total magnetic force is a maximum, or, as he himself styles it, "a point of greatest attraction." (Walker, "Magnetism," p. 317, etc.)

One of the magnetic poles he places near the meridian of Land's End, not above seven degrees from the North Pole, the other being about fifteen degrees from the North Pole in the meridian of California, while the two south magnetic poles are placed respectively about 16 and about 20 degrees from the South Pole of the earth, and 95 degrees west, 120 degrees east of London.

In order to test Halley's theory, the English government permitted him to make three voyages in the Atlantic Ocean (1698–1702), in vessels of which he had the command as post-captain. Humboldt states that these were the first expeditions equipped by any government for the establishment of a great scientific object—that of observing one of the elements of terrestrial force on which the safety of navigators is especially dependent.

The result of these voyages was the construction of the first accurate Magnetic Chart, whereon the points at which navigators have found an equal amount of variation were connected together by curved lines. This was the model of all charts of a similar nature since constructed. Halley remarked upon its completion: "The nice determination of the variation, and several other particulars in the magnetic system, is reserved for a remote posterity. All that we can hope to do is to leave behind us observations that may be confided in, and to propose hypotheses which after-ages may examine, amend or refute."

See copy of his chart in Musschenbroeck's "Essais de Physique," or, preferably, in Bouguer's "Traité de Navigation," where the lines for 1700 are in red ink, while those for 1744 are traced in black, thus readily indicating the changes in the declination.

See Cavallo, "Magnetism," and "Nat. or Exp. Phil.," vol. II., p. 273; Lloyd, "Treatise on Magnetism," 1874, p. 102; *Sci. Am. Suppl.*, No. 224, p. 3,570, 3,571; Whewell, "Hist. of the Inductive Sciences," 1859, vol. I., pp. 396-8, 435-7, 450, 451, 480, 481, and vol. II., p. 225; Giambattista Scarella, "De Magnete," 1759, vol. II.; also, G. Casali, "Sopra la Grandine, etc.," 1767.

AURORA BOREALIS, OR NORTHERN POLAR LIGHT.

Dr. Halley was the first to give (*Phil. Trans.*, No. 347) a distinct history of this phenomenon, which has certainly an electric as well as magnetic origin, and to which Gassendi first gave the name it now bears, as has been stated at A. D. 1632.

* Continued from THE ELECTRICAL WORLD, June 13, 1891.

The Practical Value of Scientific Investigation as Illustrated by the Work of Faraday and Maxwell.

BY PROF. ARTHUR L. KIMBALL.

It is impossible to escape the pressure of the so-called practical world. You will feel more and more the reaction of that influence upon yourselves, and happy will you be if there does not result a loss of enthusiasm in your work. Of what interest is it to our fellow men whether the sea spider is really a spider or a crab, to say nothing of other investigations? And, no doubt, many investigations undertaken even in the green fields of literature seem to have treasured up only husks and withered leaves and uncouth, barren forms, neglecting the dewy blossoms and graceful living sprays.

Evidently, it is of importance that we should consider the question, Can one work with enthusiasm in a cause which he suspects of being unworthy? And yet, the pressure of the active, bustling business world is so great that few can escape its influence so far as to be indifferent to its opinion. It would be difficult to ignore this opinion, even if it were right to do so; but as honest and earnest men we cannot do otherwise than face and answer it. That a true conclusion may be reached, let me ask, what are the world's treasures? what are the choicest results of civilization? We shall hardly go far astray in enumerating good government, securing justice and due liberty to all; then great ideas, poems, works of literature and art and the truths of science, all things contributing to the intellectual development of the race, and finally great inventions by which not only is labor saved and material comforts multiplied, but knowledge is diffused.

It would be a great error to suppose that successful business men have not contributed toward this heritage. Accumulated wealth has had much to do with the development of the treasures of the world; its railroads and telegraphs minister to our needs, both physical and intellectual, and whoever buys a worthy book or a noble picture has his part in the progress. Indeed, who would dare in the face of this audience and in view of the splendid gift which founded this university, as well as of the others which have followed in its train, and which have fostered whatever contributions it may have made to human knowledge, to say that wealth cannot be made an important instrument in advancing even the intellectual development of the race? But it is by the student and individual worker that the advance must be directly made. Wealth can encourage these, but it is powerless without them. It is, therefore, the great function of a university to foster this spirit of devotion to ideals, to hold up a high standard of intellectual life, to encourage the pursuit of the truth for the truth's sake, and without thought of any immediate gain, knowing well that for real progress there must be a class of men who are willing to give laborious days and weeks, and even years, to the patient, careful searching out of the truth. What though some investigations may not seem to have any possible result which shall be at all commensurate with the effort, without this class of investigators there would be scarcely any progress at all.

The words of Faraday, who was a wise man as well as a prince of investigators, have a peculiar interest in this connection. Said he to Tyndall: "There is nothing so prolific of utilities as abstractions;" and no better illustration of the truth of this remark can be found than in his own work and its outcome. See him in his laboratory trying to see whether a current of electricity flowing in a coil of wire will start another current in a coil placed near it. The wires are connected to the galvanometer which is to detect the current, but there is no motion of the needle: disappointed, he stops the flow of his main current, and instantly there is a slight motion of the needle—perhaps it was jarred, but really it was not—and the trifling circumstance is examined more carefully.

What a useless waste of time! says one. But in that moment was born the age of electricity. In this instance the resulting good was a practical utility that all can readily understand in its bearing on our material prosperity.

Turn for a moment to the work of James Clark Maxwell, the great Scotch physicist, who died about twelve years ago while professor of physics in the University of Cambridge, and who must rank with the first men of science of this century. He was a quiet—almost taciturn—man who might have been taken for a North Country laird, absorbed in such subjects as the theory of electricity and magnetism, the nature of color vision, the explanation of the properties of gases, by conceiving them to consist of myriads of particles, bounding and rebounding from each other and the sides of the containing vessel—a man whose insight into physical truth seemed almost infallible. Maxwell left, besides other things, a mass of scientific papers, which have recently been gathered into two splendid volumes, unintelligible to the general reader, but well repaying the careful study of him who is willing and able to follow the exact mathematical form in which they are expressed. In these abstruse papers there is developed a theory, which, before many years go by, will be as familiar to every intelligent person as the idea of the conservation of energy now is.

But, perhaps, some one will say, if it is possible that the theory can be so stated as to be understood by the wayfaring man, is it not pedantry to develop it by these obscure mathematical processes, which can only be interpreted by comparatively few? Why not write at once for the many? To this it may be said that it was only possible for a master mind to develop the relations between electrical actions and light, and that only by the aid of powerful mathematical processes. When the task is done, there are many interpreters, whose task it may be to explain and disseminate the newly found truth.

This theory, which recent experiments may almost be said to demonstrate, tells us that the medium, sometimes called the ether, through which waves of light travel from sun or star to the earth, is also concerned in all electrical and magnetic actions, and just as sound waves are sent out in the air from a rapidly vibrating body, so will waves of electrical disturbance be sent out into the surrounding space when the electricity in a conductor is made to rapidly oscillate to and fro. These waves of electrical disturbance are found to have the same velocity as light waves, and they are a disturbance of the same medium—the ether—in which light waves exist; the conclusion at once follows that waves of light and waves of electrical disturbance are the same thing, and each glowing particle which sends out waves of light is a centre of electrical disturbance, in which the vibrations are taking place with almost inconceivable rapidity.

To have revealed such a truth to the world is an incalculable boon. Our eyes are opened to a new unity in nature; a new and comprehensive view of the outer world is possible to us. Our vision is clearer, and our spirits are lifted by the sense of an achievement in which the whole race has an interest.

*Extract from an address at the commencement exercises of Johns Hopkins University.

Rapid Transit by Electric Motors: A Challenge.*

BY F. J. SPRAGUE.

The Rapid Transit Commission of New York recently announced a decision in regard to a route, construction and motive power, which was founded on extensive investigation, provided well for the future growth of the city, and met with general commendation. Since this decision was made, its wisdom has in certain quarters, presumably representing existing corporate interests, been most industriously attacked, and one of the principal criticisms has been that upon motive power. So far as these relate to any form of propulsion other than electric they are sound, but when directed against that particular method they are not so.

These criticisms are unquestionably dictated by one of two reasons; either they are intended to make the raising of capital for the new enterprise difficult by assailing the soundness of the commission's decision, regardless of facts, in which case all argument is useless, or they are founded on a real belief in the inability of electric motors to do the work required.

The form this comment has taken is that there is no electric motor yet "invented" which can propel even one loaded elevated car 30 miles an hour. The objection thus embodied can be easily disposed of if those making it are firm enough in their belief to put it to practical test. It is, of course, essential before money is subscribed for the new road that confidence should exist that electric motors can do what is claimed for them, and it may be necessary to make an actual demonstration on a large scale without committing the construction company to be subsequently formed to any particular system.

Having been somewhat actively identified with the development of electric railways in this country, and having urged upon the commission the necessity of electric propulsion, I am entirely ready to make a demonstration as follows:

Let a section two miles long be provided on the Second Avenue, the Suburban or the New York & Northern Railway, which shall fairly represent a station section of the express track on the proposed underground road, for use at night when not required for regular traffic.

Set apart a train of six standard elevated cars. These will weigh when empty 71 tons, and can carry when crowded to the utmost about 500 passengers, weighing 37 tons, making a net weight of train without motive power of 108 tons.

Let this loaded six-car train be propelled in two ways:

1. By a separate electric locomotive.

2. By a system of motors, one on each truck, all controlled from a pilot locomotive.

Let the condition of operation be:

1. A maximum speed of not less than 40 miles per hour on a level.

2. Power to stop the train without the use of brake shoes, and independently of the main station current.

These requirements, both as to weight and speed, are double those now characterizing the operation of the London road, and represent a capacity of eight times that mentioned in the criticism.

I will undertake to make this demonstration prior to the formation of a construction company, with free subsequent competition for regular equipment under either of these conditions:

1. The Rapid Transit Commission to require the successful bidder for the franchise to pay the costs of the experiment to an amount not exceeding $50,000.

2. The forfeiture of a like sum, in case I succeed within a specified time, by any person or newspaper that will take up my challenge.

3. On the other hand, entire loss to me if I fail.

4. The time to be four months from acceptance of this proposal, barring labor troubles, with one month leeway, at a forfeiture to me of $100 a day for each day of the month over the four months, and a premium of like amount for every day under four months. If the cost of the experiment shall be less than $50,000, the saving to go to the benefit of whoever pays for the demonstration.

It will be noted that this experiment is entirely at my personal risk, with time limitation, and without any direct pecuniary value to me, but is proposed to demonstrate the soundness of the decision made.

As an evidence of my faith, I am ready to deposit a sum which will guarantee the good faith of this proposal.

*Addressed to the Rapid Transit Commission of New York City.

High Steam Pressures in Electric Light Plants.

Considerable interest has lately been taken in the subject of carrying high steam pressures for compound, triple expansion and quadruple expansion engines in connection with the operation of electric light, electric railway and other plants of a similar character. To those who are connected with the operation of these plants the following table will prove of interest. It gives the various installations which have been made in foreign countries of Babcock & Wilcox boilers of high pressure, by the Glasgow factory of the Babcock & Wilcox Company. The pressures given in the last column are those which are in actual daily use in the various plants mentioned, and, as will be seen, many of them are above 200 pounds.

In this country the Babcock & Wilcox Company has put out a large number of boilers at equally high pressures, among which are those built for the Wood Vulcanizing Company, of New York City, which have been running at 235 pounds pressure in daily service for several years past. Another notable installation is a battery of four 100 h. p. boilers which has recently been erected at the Baldwin locomotive works in Philadelphia to carry 225 pounds pressure. A similar installation is now being erected for the Schenectady locomotive works. Considering the demands for greater economy not only in the use of fuel but also in the space occupied by boiler installations, the following table is of great interest:

NAME, TRADE AND ADDRESS.	Testing pressure.	No. of boilers.	Total h. p.	Working pressure.
Cie. des Tramways du Departement du Nord, France	330	2	135	230
Compagnie des Tramways et Omnibus, Lyons, France	340	2	90	240
The London Electric Supply Corporation, Ltd., Deptford	200	6	1,500	200
The London Electric Supply Corporation, Ltd., Deptford	300	6	1,500	200
S. Z. de Ferranti, Electrician, London	260	1	85	200
The London Electric Supply Corporation, Ltd., Deptford, *Third Order*	300	1	93	200
The London Electric Supply Corporation, Ltd., Deptford, *Fourth Order*	300	6	1,500	200
The London Electric Supply Corporation, Ltd., Deptford, *Fifth Order*	300	6	1,500	200
La Cie. des Tramways et Omnibus de Lyons, *Second Order*	330	1	70	228
Tramways de la Seine, Courbevoie, France, *Third Order*	330	3	156	240
Elwell-Parker & Co., Limited, London	300	1	120	200
S. Z. de Ferranti, Electrician, London, *Second Order*	300	1	120	200
S. Z. de Ferranti, Electrician, London, *Third Order*	300	1	120	200
S. Z. de Ferranti, Electrician, London, *Fourth Order*	300	1	120	200
S. Z. de Ferranti, Electrician, London, *Fifth Order*	300	1	120	200
The Electrical Construction Syndicate, Limited, London	300	9	1,404	200
S. Z. de Ferranti, Electrician, London, *Sixth Order*	300	1	120	200
S. Z. de Ferranti, Electrician, London, *Seventh Order*	300	1	120	200
Troller Frères, Electricians, Lucerne, Switzerland	270	1	244	180
Siemens & Halske, Electricians, Charlottenburg, Berlin	240	3	660	180
Ganz & Co., Electricians, Buda-Pesth, Hungary	225	3	420	180

Test of the Electric Street Railway Plant at Champaign and Urbana, Ill.*

BY W. A. BOYD.

Tests were made on an electric street railway plant consisting of an 80 h. p. Ideal engine, making 250 revolutions per minute, driving a United States dynamo of 40,000 watts capacity. The method of driving is by friction belts between the pulleys. The engine pulley is six feet in diameter and the dynamo pulley about three feet. Four belts, four and one-half inches wide, cover the circumference of the dynamo pulley. These are prevented from coming off by flanges on the pulley. The pressure between the pulleys is maintained by a screw on the sliding frame of the dynamo.

This plant furnishes power for about two miles of street car track between the cities of Champaign and Urbana, Ill., also power for two small motors and about 100 incandescent lights. Ordinarily two motor cars, carrying motors of twenty nominal horse power each, are run. For additional traffic trailers and more motor cars are added.

Ten tests of this plant were made, each test lasting 20 minutes, this being the length of one complete trip. The tests were begun when the cars were at the end of the line. Indicator cards were taken each minute during the test. During this time speed indicators were run continuously

*From the *Technograph*.

from the engine and dynamo shafts. The speed of the engine, while taking a card, was read from a tachometer.

In the morning, between the hours of 9 and 12, the power required varied from 9.1 to 54.6 h. p. The average for the time, while running two cars only, was 20.7 h. p. In the afternoon, between the hours of 2 and 5, the power ranged from 11.5 to 55.23 h. p. The average power required during the time was 21.07 h. p. The average power required for the day was 20.88 h. p.

To determine the frictional loss due to increased pressure on the bearings, successive positions of the tightener screw were arranged, advancing the dynamo by thirty-seconds of an inch. Table I. gives the average of a number of cards taken at these positions. Of these positions Nos. 1–5 are below the limit for ordinary running, and No. 10 is above the limit for cool bearings. Table II. gives another set of values taken at a later time for positions advancing the dynamo by sixty-fourths of an inch. The positions, one to four in the second set, lie between six and eight in the first set. They show a slight increase in engine friction, but a decided decrease in the total friction.

TABLE I.

Engine	Dynamo and engine friction.									
	1	2	3	4	5	6	7	8	9	10
3.047	4.318	4.583	4.774	4.71	4.871	4.418	5.184	5.705	5.831	6.498

TABLE II.

Engine.	Dynamo and engine friction.			
	1	2	3	4
3.312	3.77	4.327	4.619	4.338

TABLE III.

Set.	Position.	I. H. P.	Eng. friction.	H. P. trans.	Slip per cent	Mech. loss H. P.
1	4	20.036	3.312	16.724	.38	1.522
2	4	19 875	3.312	16.563	.383	1.522
3	3	19.549	3.312	16.237	.85	1.307
4	3	19.45	3.312	16 138	1.387	1.307
5	2	28.92	3.312	25.608	1.555	1.015
6	1	29.01	3.312	25.698	3.087	.458

To determine the velocity ratio of driver and follower, continuous readings were taken from both while running light. The value thus obtained was compared with the values for different positions obtained when running cars, and the per cent. slip calculated for these positions. These results are given in Table III., together with the mechanical losses due to friction. An examination of this table shows that for all powers under 30 h. p. the total sum of frictional losses and losses due to slip is a minimum for the loose position; while for powers greater than 30 the most economical point is at the tighter positions.

In order to obtain the pressure on the bearings in this case, a lever 48 inches long was bolted to the tightener wheel, and the pull required read from a spring balance. By several trials the pull required to move the dynamo on its frame alone was 14 pounds. The pull required to move the dynamo while in running position was 20½ pounds. The mean radius of the screw was .6887 inch, and the pitch one-fourth of an inch. Using .15 as the coefficient of friction, the pressure on the bearings was found to be 2,160 pounds.

As a comparison between this system of driving and driving by means of belting, a calculation was made taking as an extreme case the distance between driver and follower equal to one inch. Using the ordinary formulæ for belting, the pressure on the bearings necessary to transmit the maximum power was found to be 884 pounds. This gives the pressure on the bearings but little more than two-fifths of the pressure required by the present method of driving. The width of the belt taking into consideration centrifugal action was calculated and found to be ten inches for a one-quarter inch belt.

These results seem to show that for street railway work, or where the demands for power vary so much, the ordinary belt driving is superior in economy to driving direct by means of friction pulleys.

The Reno Underground Railway.

We give herewith a couple of views showing the construction contemplated for the Reno tunnel system, one of the prominent plans for underground work considered by the Rapid Transit Commission. In a previous issue we gave a general account of the methods of construction employed, so that the present note will be more on the details than on the fundamental engineering character of the plan.

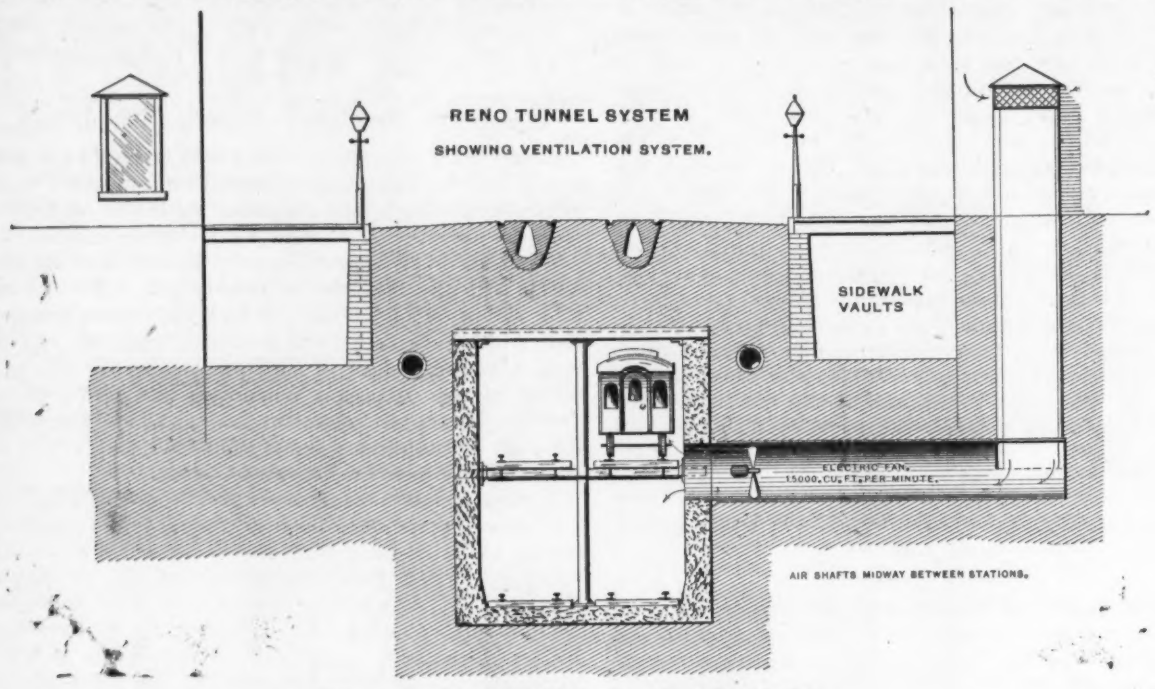


FIG. 2.—RENO SYSTEM OF VENTILATION.

Fig. 1 shows a cast-iron construction that it is proposed to substitute for the concrete walls and masonry in places where, from very great dampness of the ground or other special reasons, the concrete walls of the general system prove undesirable. For example, in running a line of Reno tunnel up Broadway, the cast-iron construction would be employed for a considerable portion of the length in the lower part of the city, below Grand street for instance. In this the walls, roofs and floors are composed of flanged panels of cast iron about two feet in width, set in place in the rear of a shield pushed forward hydraulically; this shield will not be circular, as in most cases where it has been employed, but rectangular in section to cut the tunnel to the exact size necessary. The shield will be advanced for two feet, and then the eight iron panels will be placed in position and bolted at the flanges, after which a grouting of liquid cement will be forced through holes left for the purpose and form a solid packing that both prevents the entrance of water and shields the iron from corrosion. The method is a common one in tunneling work, and has been employed on the Croton Aqueduct. In the upper part of the city the original plans described in our previous article on the subject would be followed as being simpler, cheaper and more easily applied in ground of the character to be found on that part of Manhattan Island. As before mentioned, the grouting would be freely used to make the tunnel perfectly tight and prevent any difficulties from moisture or sewer gas forcing their way in.

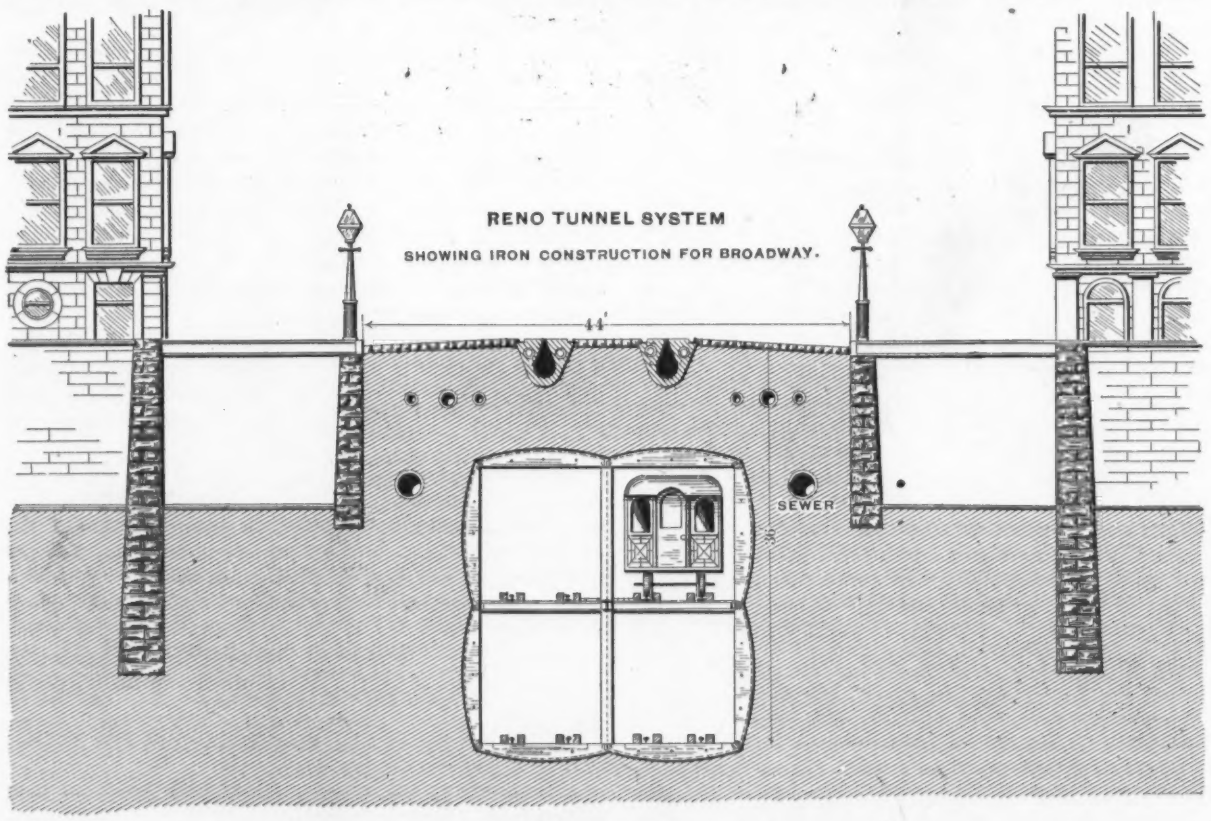


FIG. 1.—RENO CAST IRON TUNNEL.

Fig. 2 is worth special notice as showing the method of ventilation proposed. This consists in placing a 54-inch fan in a ventilating flue at each station, drawing its air from the street above and forcing it at the rate of 32,000 cubic feet per minute into the tunnel. This is quite sufficient for ventilation, even if there were no other means of keeping up the proper circulation through the motion of the trains.

As we have before said, the Reno tunnel is unusually simple and exceptionally easy of construction. The four tracks are placed in the minimum amount of space, and the stations and tracks can be reached very readily, instead of spreading the tracks and taking passengers above or beneath them to get at the express service. The double-deck tunnel certainly possesses great advantages in the matter of compactness, and, as a tunneling feat, is much easier to build on account of the far less roof space required. In the construction of a road on this principle the motive power will be, of course, electricity, and the conductors could be so placed as to allow a sufficiently high voltage to be employed to render the use of one or two large central stations sufficient for distributing power over the entire length of the line. Electric motors driven from the same source of supply would operate the ventilating fans, and the lighting of the tunnel could be carried on either from the same mains or from regular incandescent mains similarly supported. The form of insulation proposed for this work is worth a moment's notice, inasmuch as it consists of a vulcanized hardwood rod about five feet long, supported by cast-iron sockets at either end and carrying the working conductor in the middle. The result of this method is to give a stiff and firm support to the working conductor, and at the same time to reduce the amount of leakage to a minimum, inasmuch as any current escaping would be compelled to sneak along the surface of the small wood rod for about 30 inches.

In the report of the Rapid Transit Commission the use of the double-deck tunnel was spoken of in the most favorable terms for at least a part of the route proposed, and its advantages over the use of four tracks on a level are sufficient to commend it for the entire distance to be covered. With the latter construction a very wide roadbed and wide roof are both necessary, beside there being the inconvenience in access to the tracks previously noted. One of the good points of the Reno plan, with its comparatively easy construction, is the rapidity with which the work can be accomplished if it should be undertaken. With very little disturbance of the ground above and no serious undermining of the streets or interference with foundation work, it can be carried on simultaneously with a large number of headings, and the tunnel forced through to completion in much less time than would be practicable were an elaborate masonry subway to be constructed.

The engineers of the Rapid Transit Commission are now cogitating the question of methods of construction, and it seems not at all unlikely that Mr. Reno's ingenious plan will be favorably considered, for at least a considerable portion of the route. A decision in favor of an underground road is now generally conceded except by the mouthpieces of the elevated roads. It is really the only practicable solution of the rapid-transit difficulty in this city, and the sooner the work is undertaken and completed the better it will be for the citizens of this overburdened metropolis.

Some Effects of Alternating Current Flow in Circuits Having Capacity and Self-Induction.*

BY DR. J. A. FLEMING.

On December 5, 1890, Mr. Ferranti placed at my disposal two lengths of the trunk mains running from Trafalgar square to Blackfriars, for the purpose of measuring the capacity. The length of cable used was 2,399 yards, or 1.363 statute miles. The capacity of one of these lengths (No. 3 cable) was found in the usual way (taking the capacity between the inner and outer members) to be .5 microfarad for the whole length, or at the rate of .367 microfarad per statute mile. It follows from this that the specific inductive capacity of the material used is about 3.4 (air = 1). Using the other cable No. 4), the copper resistance was found to be .324 legal ohm, or .328 B. A. unit per statute mile, reckoning the resistance per mile run of the cable, and including, therefore, both the inner and outer conductor. The insulation resistance between the inner and outer member of the first cable was found to be at the rate of 720 megohms per mile. The instruments used in taking these measurements were a half-microfarad condenser by Dr. Muirhead, and a legal ohm Wheatstone bridge and megohm standard, kindly lent by Messrs. Elliott Bros. for the purpose. The temperature of the ground on that day was near the freezing point, and Nature saved us the trouble of reducing the values to zero centigrade.

The remaining element required is the inductance of the cable per mile. Fortunately, the form of cable which is the best for practical reasons is almost the only case in which the inductance can with no great difficulty be calculated with any required degree of accuracy from the dimensions of the cable. Lord Rayleigh has solved for us the problem of the inductance of a pair of concentric conductors placed co-axially. His formula, as given in his paper in the *Philosophical Magazine* of May, 1886, p. 385, is as follows, when translated into my nomenclature, and the values of the magnetic permeabilities of the materials all taken as equal to unity:

$$L = \text{inductance per unit of length} = 2 \log \frac{R_3}{R_2} + \frac{2}{R_2^2 - R_1^2}\left(\frac{R_2^2 - 3R_1^2}{4} + \frac{R_1^4}{R_2^2 - R_1^2} \log \frac{R_2}{R_1}\right) + \frac{2}{R_4^2 - R_3^2}\left(\frac{R_3^2 - 3R_4}{4} + \frac{R_4^4}{R^2 - R_3^2} \log \frac{R_4}{R}\right).$$

The logarithms are all Napierian, and the values of R_1, R_2, R_3 and R_4 may be taken in any units, as only their ratios are required.

The values of the chief functions of the radii of the tubes have been given above, and, making the substitution, we have for the inductance of one centimetre run of the cable the following value:

$$L = 2 \log 2.27 + 1.6872 \log 1.444 + 223.068 \log 1.051 - (.9185 + 10.561).$$

Remembering that the logarithms here are Napierian, and that the logarithms to base 10 must be multiplied by 2.3026 to reduce them to the Napierian base, we have as a final result of the calculation,

$$L = 1.7755 \text{ centimetres.}$$

Hence, since one statute mile = 160,931.5 centimetres, the inductance per statute mile of the Ferranti cable is 285,734 centimetres = .0002857 of a henry, or 285.7 microhenrys.

This result will be accurate to just the extent to which the diametrical measurements of the conductors are accurate.

Collecting our results, we have for one statute mile run of the Ferranti trunk main the following values as deduced from measurements on the particular lengths employed:

$$R = \left\{\begin{array}{l}\text{Copper resistance at 0° Cent. of lead and return.....}\end{array}\right\} = \left\{\begin{array}{l}.324 \text{ legal ohm per mile.}\end{array}\right.$$

$$K = \left\{\begin{array}{l}\text{Insulation resistance of length measured at rate of .....}\end{array}\right\} = \left\{\begin{array}{l}720 \text{ megohms per mile between inner and outer conductor.}\end{array}\right.$$

$$C = \left\{\begin{array}{l}\text{Electrostatic capacity between inner and outer conductor.....}\end{array}\right\} = \left\{\begin{array}{l}.367 \text{ microfarad per mile.}\end{array}\right.$$

L = Inductance..... = 285.7 microhenrys per mile.

The formula given above for the inductance per unit of length can be applied to stranded concentric cables with a fair degree of approach to accuracy.

Suppose that we are sending periodic currents having a frequency of 67 through the Ferranti cables, then, if n = frequency = 67, $2\pi n = 421 = p$, and $4\pi^2 n^2 = p^2 = 177{,}241$.

Hence, since $R = .324$ ohm, and $L = .000286$ henry we have $\sqrt{R^2 + p^2 L^2} = .3455$ ohm for the impedance per mile, and we see that at this frequency the impedance exceeds the resistance by about seven per cent. of the latter.

From the data thus given other functions of the capacity C, inductance L, resistance R, and impedance I per mile can be built up, which will be required presently. These are—

$$P^2 = \frac{Cp}{2}\left\{\sqrt{R^2 + p^2 L^2} - pL\right\} = .00001738;$$

$$Q = \frac{Cp}{2}\left\{\sqrt{R^2 + p^2 L^2} + pL\right\} = .00003597.$$

Hence, also,

$$P = .004168,\ Q = .005997;$$

$$P^2 + Q^2 = .00005335,\ \frac{P^2 + Q^2}{I^2} = \frac{447}{10^6};$$

$$(2PR + 2QLp) = .004147;$$

$$(2PLp^2 - 2Qp R) = -1.216.$$

* Continued from THE ELECTRICAL WORLD, June 13, 1891.

All the quantities refer to one mile run of the cable.

15. In the course of various experiments during the laying of the cable, it became evident that a conductor having so considerable an electrostatic capacity behaved in a curious manner under some circumstances when long lengths were connected up to a transformer. This behavior has been much misunderstood, and much misdescribed. Remarkable phrases have been coined with reference to it, such as "the piling up of the volts," or "packing up of the volts," which are not very lucid descriptions of what really does occur. Ingenious theories have been constructed, also, to account for phenomena which do not exist. Briefly stated, it appears to be as follows: When an insulated and sufficient length of the cable has its inner and outer members connected to the terminals either of a transformer or of an alternator having an armature of sufficient inductance, it is observed that under these conditions the potential difference between the inner and outer members, measured anywhere along the length of the cable, is generally greater than would be the potential difference of the terminals of that alternator or transformer if the cable were very short, or not present at all. This seems to hold good also when the far ends of the inner and outer members are connected together through a not very small resistance, such as a row of incandescent lamps in series, or a high-resistance voltmeter, or transformer lightly loaded. The cable acts in all apparently as one single condenser would do, and in no case, as far as is known, is there evidence of a continuous rise of pressure along the trunk mains themselves. The pressure at the London end is not found to be greater than at the Deptford end. The condenser effect is increased apparently by increase of length of the main, at least within observed limits, and in all cases the main acts as if it were a condenser bridged across between two parallel mains without capacity. When current flows into the cable there is a flux across the dielectric from inner to outer member which constitutes the *condenser current* of the mains, and the outflowing current is in general less in magnitude than the inflowing current, although not always necessarily so. The current flowing out at the London end may be called the *work current*. There is a difference in phase between the work current and the condenser current. The ingoing current is the resultant of the work and condenser current.

16. In order to examine the phenomena of these trunk mains more closely, some experiments were made on one length of nearly 12 miles of the cable by joining the conductors of two trunk mains in London, and having both ends of this gigantic loop of concentric cable at our disposal in the Deptford station. These experiments were arranged by Mr. Ferranti to give Mr. Preece, Major Cardew and me the opportunity of obtaining measurements of these condenser effects in the Ferranti trunk mains. The experiments were made on Friday, January 9, 1891, at Deptford, and Mr. Ferranti, Mr. Sparks, Mr. D'Alton, Mr. McLean and the assistant engineers took part in carrying out these measurements. The arrangements were made as follows (see Fig. 10): One of the 1,200 h. p. dynamos (No. 2) was set apart for the purpose, and excited so as to supply current at about 2,500 volts or so. The current from this dynamo was led through the primaries of two 150 h. p. transformers joined in parallel, and which raised the pressure from 2,500 to 10,000 volts. At this pressure a current from the secondaries was sent into the concentric cable at Deptford, thence to the sub-station in Trafalgar square in London by one main. This total distance is 20,224 yards, or 11.49 statute miles. Arriving back at Deptford, the current was again reduced from 10,000 to 2,500 volts, and the energy taken up in water resistance in a water tank at the latter pressure. The pressure at different parts of the system was measured by Cardew voltmeters, the high pressures being reduced by 100 : 1 pilot transformers. The currents were measured by Eversbed ammeters. The current and pressure were measured at four places, viz., at the terminals of the dynamo, at the beginning or entrance of the trunk main, at the end of the trunk main, and, after reduction, at the tank. Observers stationed at these different instruments took simultaneous observations at a signal given by the sound of a whistle, and in this way the simultaneous values of the pressure and current were obtained at these four places. The transformers used for raising and lowering the pressure were the 150 h. p. size, having on the primary side 1,120 turns of wire, of resistance 2.5 ohms, and on the secondary side 280 turns of wire, having a resistance of .2442 ohm. Hence these transformers were 4 : 1 transformers. There were, in addition, a pair of pilot transformers, which had a change ratio of 100 : 1, and which reduced from 10,000 to 100 volts for voltmeter purposes. The observations consisted in exciting the dynamo to various voltages, and observing the current and pressure at the four places named, while different loads were placed on the system by taking up more or less current in the tank.

TABLE I.—EXPERIMENTS ON THE PRESSURE DISTRIBUTION IN THE FERRANTI TRUNK MAINS.

I. No. of experiment.	II. At dynamo terminals. Pressure.	III. At dynamo terminals. Current.	IV. Dynamo pressure multiplied by 4.	V. At home end of trunk main. Pressure.	VI. At home end of trunk main. Current.	VII. At far end of trunk main. Pressure.	VIII. At far end of trunk main. Current.	IX. Pressure at tank multiplied by 4.	X. At the tank. Pressure.	XI. At the tank. Current.
1	2,177	121.4	8,708	9,060	29.2	8,950	26.5	8,610	2,160	118.2
2	2,385	119.4	9,544	10,100	31.5	9,750	28.0	9,504	2,376	117.1
3	2.458	119.4	9,832	10,300	32.0	10,120	28.0	9,840	2,460	116.0
4	2,177	119.3	8,708	9,110	29.2	8,930	26.5	8 640	2.160	116.0
5	2,311	115.2	9,244	9.700	28.7	9.570	24.8	9,408	2,352	106.5
6	2.251	110.2	9,004	9,600	27.6	9,280	24.3	9,024	2,256	105 5
7	2.568	106.1	10,272	10,490	27.0	10,070	23.3	9,792	2,448	101.6
8	1,994	108 1	7,976	8,420	26.0	8,200	23.3	7,872	1,968	100.7
9	2,448	100.0	9,792	10,170	24.0	10.690	19.0	10,128	2,532	56.6
10	2.496	92.8	9 984	10,560	22.0	10,590	17.0	10,512	2,628	56.0
11	2,400	92.8	9,600	10,360	21.5	10,490	16.3	10,224	2,556	55.5
12	2,311	64.1	9,244	9,700	17.0	9,770	Not taken.	9,600	2,400	42.2
13	2,780	41.7	9,1 0	9.870	11.0	9.900	0	9,736	2,434	0
14	2,328	41.7	9,312	9 970	11.0	10,000	0	9,880	2,470	0
15	1,620	42.7	6,480	7,240	10.0	7,350	0	7.248	1,812	0
16	1,104	24.4	4,416	5,200	5.0	5,200	0	4 964	1,241	0
17	1,212	24.4	4,848	5,500	9.0	5,500	0	5,456	1,339	0
18	1,308	24.4	5,232	5.900	9.0	5.900	0	5.740	1,435	0
19	1,800	37.6	7,200	7.920	10.0	7.920	0	7,784	1.946	0
20	2,136	48.8	8,544	9.380	12.0	9,410	0	9,244	2,311	0

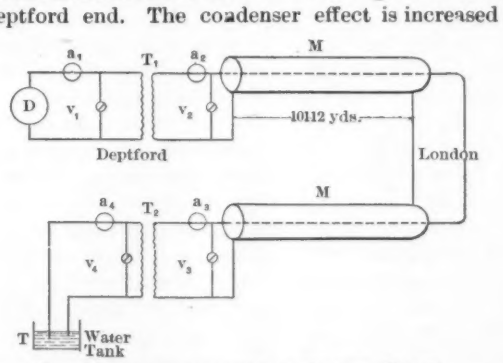


FIG. 10.—ALTERNATING CURRENT FLOW.

v_1, v_2, v_3, v_4—Voltmeters; a_1, a_2, a_3, a_4—Ammeters; *D*—Dynamo; *T*—Tank; T_1—Step-up Transformers; T_2—Step-down Transformers; *M*—Trunk Mains.

17. From a large number of observations the following are selected as showing the general results obtained, and are set forth in Table I. The first column gives a number for each experiment. The second and third give the pressure and current at the dynamo terminals. The fourth column is a series of numbers which are four times those in the second column, and are the pressures to which the 1 : 4 step-up transformers at the home end would raise the dynamo pressure if the cable were absent. The fifth and sixth columns give the pressure and current at the home, or dynamo, end of the trunk main, and it will be seen that in every case this observed pressure is greater than four times the pressure at the dynamo terminals. The seventh and eighth columns give the pressure and current at the far end of the trunk main, and it will be seen that in every case the current flowing out of the main is less than that going into it. Columns X. and XI. give the pressure and current after reduction by the step-down transformers, at which pressure the energy was taken up on water resistance in a tank. Column IX. gives the pressure on the primary, or cable, side of the 4 : 1 step-down transformers, which would be necessary to give the pressure observed at the tank if the cable were not present.

18. We have then to see how these observed values agree with theory. It must be, however, stated that these numbers and values so observed are not minutely accurate. Owing to the fact that the speed of the dynamo varied slightly, and to the fact that the Cardew voltmeters used were set vertical and not horizontal, some degree of inaccuracy exists in the readings of current and pressure, but the figures are perhaps sufficient to test the general agreement of fact with theory.

We note, first, that in the experiments at full load, when 118 ampères was being taken up in the resistance, the load on the transformers was about 340 h. p., and hence the two 150 h. p. transformers at each end joined in parallel were slightly overloaded. Under these circumstances, the inductance of the transformers at the step-up end is reduced practically to a very small value, and we may consider that the actual current of 30 ampères or so flowing in the cable can be considered to be the resultant of two superimposed currents differing about 90 degrees in phase from one another. There is, first, the *work* current of 26.5 ampères in Experiment I., which is flowing out of the cable, and which is practically in synchronism with the impressed electromotive force in the secondary circuit of the step-up transformers. Then there is the *condenser* current of the cable considered as one single condenser, which will be 90 degrees in advance in phase of the impressed electromotive force creating this charge. Hence the values of the ingoing currents given in column VI. are the resultants of the outgoing current given in column VIII., and the condenser current of the cable, which is in quadrature with the last. Hence the

magnitude of the condenser current must be the square root of the difference of the squares of the currents given in columns VI. and VIII., which may be called respectively the *resultant current* and the *work current*.

Taking the first six experiments in Table I., we calculate from them the square root of the difference of the squares of the currents in columns VI. and VIII. of Table I., and write them as in Table II. below.

TABLE II.

Resultant current going into cable $= a$.	Work current coming out of cable $= b$.	Condenser current of cable $= \sqrt{a^2 - b^2}$.
Ampères.	Ampères.	Ampères.
29.2	26.5	12.2
31.5	28.0	14.4
32.0	28.0	15.5
29.2	26.5	12.2
28.7	24.8	14 4
27.6	24.3	13.1

Unfortunately, the speeds of the dynamo were not taken at each observation; but the normal frequency of the current from these dynamos is 67, and in these experiments the dynamo speeds were marked as rather below the normal. If $n = 67$, $2\pi n = p = 421$. It is probable that the value of p was not greater than 400 in these experiments. We have seen (equation 2, *ante*) that if v is the instantaneous potential difference of the condenser terminals, and i the current flowing into it at any instant, $i = C\frac{dv}{dt}$. Hence, on the assumption of a simple periodic variation of the current, we may write p for $\frac{d}{dt}$, and put as the value of the square root of the mean square of the condenser current, I, the expression,

$$I = pCV,$$

where C is the capacity, and V is the potential difference of the terminals of the condenser as read by an electrostatic or Cardew voltmeter. It then follows that the capacity of the cable is determinable from the values of the condenser current, I, the pressure, V, as read at the step-up end, and from the known value of p.

We may examine how far the capacity value so deduced agrees with measurement.

We tabulate in columns the values of the condenser currents I, found from Table II., and set against these the mean potential difference of the inner and outer members of the cable as the mean potential difference of the surfaces of the condenser. Calling these last values V, we then calculate the capacity C, in microfarads from the formula

$$C = \frac{I}{pV} \times 10^6,$$

on the assumption that $p = 400$. These results are set down in Table III. The values of the potential V are the means of the pressures given in columns V. and VII. of Table I. as the pressures at the step-up and step-down ends of the trunk main.

TABLE III.

Condenser currents, I, in ampères taken from Table II.	Mean potential difference of condenser surfaces, V, of cable in volts.	Calculated capacity for the whole length of cable in microfarads.
12.2	9,005	3.4
14.4	9,935	3.6
15.5	10,210	3.8
12.2	9,020	3.4
14.4	9,635	3.7
13.1	9,440	3.5

The mean electrostatic capacity of the 11.5 statute miles of the cable in use is therefore about 3.6 microfarads, as deduced from these experiments. On the day following these experiments the electrostatic capacity was measured at Deptford by Mr. H. R. Kempe, using a microfarad standard and a battery of about 18 Daniell cells, and taking galvanometer throw observations in the usual way. Mr. Kempe found the capacity, under these circumstances, of the respective mains to be about 1.98 and 2.02 microfarads, or in all about four microfarads. Accordingly, we see that the capacity, as deduced from the mean calculated condenser currents and the observed pressures at the ends of the mains, comes out a little low compared with the measured steady value; but the speeds and pressures were hardly observed with sufficient accuracy to make a closer agreement very likely, and the condenser current values are probably affected by some errors. It may be observed that the effect of a small but definite inductance in the fine-wire circuit of the step-up end existing unannulled at full load would be to lower the condenser currents, and hence to lower the calculated capacity. I think it is pretty clear that what may be called the normal condenser current of the 11.5 statute miles of the trunk mains is about 14 or 16 ampères under a working pressure of 10,000 volts at the step-up end of the main, and at a frequency of about 67 for the circuit. This is what is generally observed.

On one occasion, when the writer was engaged with Mr. Ferranti in testing the trunk mains, we had a similar arrangement of the system to that above described, viz., a length of 11.5 statute miles of trunk main looped in London through two step-down and step-up transformers in parellel, and a similar set of transformers at Deptford.

Two 100 c. p. lamps were put on the far end of the system at Deptford, just to give indication of a current flowing through the system; otherwise there was no load. When the dynamos were excited so as to give 2,500 volts on the primary side of the step-up transformers, and this was raised to 10,000 volts in the mains, we found a current of about 64 ampères going out of the dynamo at 2,500 volts. This would correspond to 16 ampères or so in the trunk mains. The actual working current at this time was merely the magnetizing current of the step-down transformers and the normal current required for the lamps. Hence this experiment agreed in showing that the normal condenser current of the trunk mains at 10,000 volts pressure and a frequency of 67 is about 1.4 ampères per mile run of the cable.

19. Let us next examine how far the observations taken with no load on the secondaries of the step-down transformers agree with the foregoing. In this case we restrict our view to the last eight observations recorded on Table I. The numbers in column IV. give us at once the condenser current of the cable, because there is no sensible current flowing out of the cable except the negligible magnetizing current of the transformers.

TABLE IV.

Condenser current, I, in ampères.	Mean potential difference of condenser surfaces of the cable in volts.	Calculated capacity for the whole length in microfarads.
11	9,885	2.8
11	9,985	2.8
10	7,295	3.4
5	5,200	2.4
9	5,500	4 1
9	5,900	3.8
10	7,920	3.1
12	9,395	3.2

The variation in the values of the capacity shows that the measurements of the condenser currents are probably affected by considerable errors; and this is likely, seeing that the ammeters on the end of the trunk main would not read with sufficient accuracy to detect a difference of one or two ampères at these low readings. Hence all we can say is that the mean capacity of the cable, as deduced from the observations at no load—viz., 3.3 microfarads—is not extravagantly different from that obtained by observations at full load.

If we take one of the observations at half load—say No. 10 in Table I.—we arrive at the same result; for the ingoing and outgoing currents in the trunk main are then 22 and 17 ampères, and the difference of their squares is 14, which is probably nearly the condenser current in this case; and the mean potential difference of the surfaces of the cable is 10,560 volts; and hence, as before, the capacity comes out 3.3 microfarads for the whole length. Hence all the observations agree in giving a capacity of from 3.3 to 3.6 microfarads for the total cable in use. It may well be questioned whether for this paraffined paper dielectric the capacity as determined by a prolonged charge and discharge gives a value which is correctly expressive of the true working capacity of the cable under rapid alternations of charge. It must be remembered that paraffined paper presents usually a considerable absorption effect, and the value of 4 microfarads for the 11.5 miles, obtained by the usual ballistic galvanometer method, may be, and perhaps is, a value which is higher than that which correctly expresses the true working capacity of the cable under rapidly reversed electric stresses. It is important to have this point investigated for the dielectrics in use in the manufacture of types of concentric cables now employed.

20. Passing to the examination of other points indicated by the observations in Table I. we see that the mean potential difference of the two conductors of the cable is always greater than four times the dynamo terminal pressure as given in column IV. That is to say, these figures show that the pressure in the trunk main at the dynamo end is always greater than would be the pressure at the terminals of the step-up transformers if the trunk mains were disconnected. This may be said to be the fundamental phenomena which have been much dis-described and misunderstood. The values of the pressures as read at the dynamo terminals and at the two ends of the trunk mains show that whenever the system is loaded and there is a fairly heavy load there is a fall of pressure down the cable, as there should be; although the actual figures seem to show that this fall of pressure is not quite equal in value to the product of the values of the true resistance of the cable and the current flowing through it. Those cases in which the figures in Table I. seem to show a rise of pressure along the main cannot be accepted as representing the actual facts. When the cable is relieved of all working current, and only traversed by a condenser current, the figures show that the cable is either all at one pressure all along or else that there may be a slight rise from the step-up end to the step-down end of the cable. I think, however, that there is no good evidence of this rise of pressure from end to end of the cable when not loaded with external load. The chief fact is that, whereas the step-up transformers would, if existing alone, raise the dynamo pressure fourfold, we find that when the cable is heavily loaded the mean potential difference of the conductors exceeds four times the dynamo terminal pressure by something like 5 per cent.; and when the external load is removed that excess pressure more nearly amounts to about 10 or 15 per cent.

The general fact is quite in accordance with the foregoing theory. When the step up transformers are heavily loaded the inductance of their secondary circuits is practically annulled or very much reduced; when they are lightly loaded it is at once increased. We have seen, in discussing the clock diagram of electromotive forces as applied to this condenser problem, that the increase in pressure which takes place is always an evidence of the presence of inductance in the charging circuit, and that this rise of pressure will augment with increase of inductance in the line or in the step-up transformer. We are unable to test how far the general rise of pressure is in accordance with the foregoing theory, because we have no means of measuring the true mean inductance of the secondary, or high-pressure, side of the step-up transformers. The presence of capacity in the line always keeps down the inductance of the transformer, because it compels a rather large current to flow into it from the dynamo, even when the work current flowing out of the cable is zero, or nothing more than the magnetizing current of the step-down transformers.

A Thermo-Electric Method of Studying Cylinder Condensation in Steam Engine Cylinders.*

BY PROF. EDWIN H. HALL.

The subject of cylinder condensation is one that possibly would come more aptly before the mechanical engineers than before the electrical engineers, and yet most electrical engineers are to a greater or less extent mechanical engineers, and the time seems not yet to be near when we can dispense with the steam engine in the practical applications of electricity. The methods for turning the energy of coal directly into electric currents I believe have not yet been put into application. The subject of cylinder condensation is one that has always been prominent in the study of the steam engine. Before the time of James Watt, as you are all aware, at every stroke the cylinder was filled with steam, and then it was cooled down by pouring water on the outside or by admitting water into the inside, so that whenever the steam was admitted it found the cylinder cool. A large part of the steam admitted at every stroke was turned into water at once on admission, and some of it was doubtless turned back into steam during the stroke, but much of it went out as water in the end. Watt introduced the independent condenser, by means of which the steam is removed from the cylinder without cooling the latter down as it was cooled before; and yet it is still believed that a very considerable part of all the steam that enters the cylinder is condensed upon the inner surface of the cylinder; that some of this is re-evaporated during the stroke, but that a very considerable part remains as liquid at the end of the forward stroke, and is only turned back into steam during the back stroke, when it is a disadvantage rather than an advantage, for it has to be expelled by the returning piston. It is considered that in some engines as much as 25 per cent. of all the steam that enters the cylinder goes through the cylinder as water—that is, during the forward part of the stroke. Writers upon steam engineering have devoted a good deal of attention to the discussion of the cause of cylinder condensation, with perhaps less suggestions for remedy. The cause of cylinder condensation is this, that when the cylinder is thrown into communication with the condenser, rapid evaporation takes place of the water remaining on the wall, and that rapid evaporation under the diminished pressure cools greatly the cylinder wall. A little more than two years ago (Jan. 17, 1889), Mr. Dickerson gave an address before the Electric Club of New York, I think, in which he advanced the proposition that the peculiar character of the indicator card of a steam engine which was supposed to show cylinder condensation and re-evaporation was due to leakage by the valves—leakage in by the valves at one part of the stroke, leakage out by the valves at another part of the stroke. He made the statement that the steamers in the waters about New York City would travel four or five miles an hour with the valve between the boiler and the cylinder closed. I do not know how accurate that statement was. I have never seen any statement in contradiction of it. Mr. Dickerson's paper excited my interest—perhaps more than it would have excited my interest if I had been a trained steam engineer. I knew that this was a matter in controversy between steam engineers; that they were by no means at one as to the amount of cylinder condensation, and by no means in agreement as to what caused the cylinder condensation, some believing that the steam coming in here at A (Fig. 1) was cooled by contact with a layer of water remaining over from the previous stroke—the layer of water upon the inside of the cylinder. They thought that you could hardly account by the action of the iron alone for the very sudden condensation of the large amount of steam that is condensed. Mr. Dickerson's paper, then, stimulated me to undertake an investigation of this matter in a direction in which it had not been approached before, so far as I know. Steam engineers have invariably, so far as I know, examined this question by study of the indicator card, examining the pressure at different parts of the stroke, the pressure and volume, and finding out how much steam they indicate. Knowing the pressure at this part of the stroke C (Fig. 2), and the volume occupied by the steam, we can tell what weight of steam there is in the cylinder as *steam*. It is found frequently that there is more steam in the cylinder at the end of the stroke than at the beginning of the expansion. According to Mr. Dickerson, that was due to the leakage by the valves by which steam was admitted,

* A paper read before the American Institute of Electrical Engineers, May 20, 1891.

when the pressure in the cylinder fell low. It seemed to me that we might test the question how much heat enters the cylinder walls by a thermo-electric method. Let this (*i. e.*, Fig. 1, making a sketch) represent the thickness of the cylinder wall. Now this, *C*, is a hole which in the engine which I have used is bored for attaching the indicator. It is a hole about three-quarters of an inch in diameter. The thickness of the wall is about three-quarters of an inch—a little more than that. I screwed into that hole a plug (Fig. 3) having at this end, *i*, a slice of iron—I had steel at first—of known thickness. Here is a hole going through the plug to that slice. Here is another. Into that hole I put a bar of antimony, *A*; into this hole a bar of bismuth, *B*. The two were insulated from the plug. It is known to all of you that bismuth and antimony make an excellent thermo-electric pair—the best that is in practi-

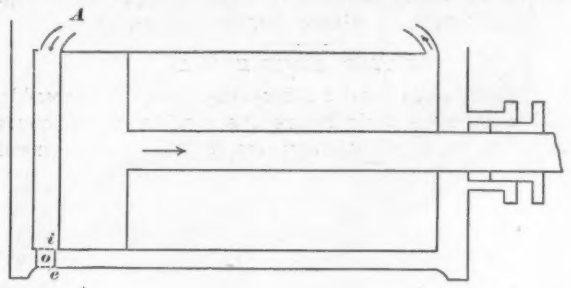


FIG. 1.—STUDY OF CYLINDER CONDENSATION.

cal use. If I connect the antimony with the copper wire *g*, the bismuth with the copper wire *c*, and lead those wires to a galvanometer, I shall get a current through that galvanometer whenever the two junctions here, *a* and *b*, are at a different temperature from the section where the antimony and the bismuth strike this slice of iron. If I put the ends of these rods of bismuth and antimony into a pot of paraffine and heat that paraffine, when I get the temperature of these two junctions *a* and *b*, where the copper joins the bismuth and antimony, the same as the temperature where the antimony and bismuth strike the iron the current will cease. If the temperature here is below the temperature there, I get the current in one direction. If the temperature here is higher than the temperature there, I get a current in the opposite direction. That was the beginning of the method. But it presently occurred to me that it would not do to use bismuth and antimony, for the reason that the heat conductivity of those substances is too different from that of iron. My purpose was to find what the temperature was at a certain thickness in the cylinder wall at a certain part of the stroke. (I close this circuit *g c* at a particular part of the stroke by means of a cam upon the crank. I can close the circuit at any part of the stroke for a short time.)

It being my purpose, I say, to find what the temperature is at a particular depth in the iron, I wished to have that temperature as exactly as possible what it would be if this iron were in a normal condition—that is, if this were in a solid cylinder instead of being in a prepared plug. To get that I found it necessary to have for these bars *A* and *B* Fig. 3 a heat conductivity which was more nearly like that of iron than the heat conductivity of antimony and bismuth is. So I cast about for some metal which would *with iron itself* make a good thermo-electric couple, and of which the heat conductivity would be very like that of iron. Nickel suggested itself. Nickel and iron make a very good thermo-electric pair. I determined to make my

FIG. 2.—STUDY OF CYLINDER CONDENSATION.

plug in this way. Here (Fig. 4) is a plug with a hole bored completely through it. Here is a slice of cast iron, *S*, ground to a particular thickness, which is screwed on at the end of the plug, making a steam-tight joint—at least I meant it to be steam tight.†

Into this hole I put a core of nickel insulated from the iron, except here, where it strikes the slice. The nickel is soldered to the iron in this way: The slice is *tinned* very thinly; the end of the nickel core is also tinned. The two are heated very hot, and then in a vise they are held together until they are cooled, so that the thickness of the solder there is not more than a thousandth of an inch. The soldering was done with the slice and the nickel core in place, the slice being screwed to the plug and the core being surrounded with a single layer of paper to keep it free from the iron, except at the bottom of the hole. Slice and core were removed from the plug after soldering, and the solder which had been squeezed out from the joint by the action of the vise was carefully turned off in a lathe. The distance from the outer end of the core to the farther surface of the slice was measured carefully before soldering and after soldering. In no case did these measurements show the thickness of the solder to be as much as .02 millimetre.

I know very definitely, then, the depth at which the contact takes place. Now, as to the heat conductivity of nickel, I can find no data in the books. I believe no information in regard to it turned up in my studies. But I know from the relation of its electric conductivity to that of iron that the heat conductivity ought to be nearly like that of iron, for usually heat conductivity and electric conductivity go hand in hand. I had to have a bar of nickel made to make the determination. I had a bar of nickel made about a yard long and about one square inch in cross section, and I had considerable trouble to get it. I determined the heat conductivity of that by comparison with a similar bar of cast iron. I found that the best conductivity of nickel is rather less than that of cast iron, perhaps 15 or 20 per cent. less,* but still nearer the heat conductivity of cast iron than any other metal that I could get that would make with iron a good thermo-electric junction. The specific heat of nickel is near that of iron, which again is as important, perhaps, as the matter of the thermal conductivity. Now, from the nickel core I lead a nickel wire, both being made from the same bar of which I had determined the conductivity from the iron and iron wire. This and the one of nickel were slender bars about 15 cm. long rather than wires proper. These are not drawn to scale These junctions *i*

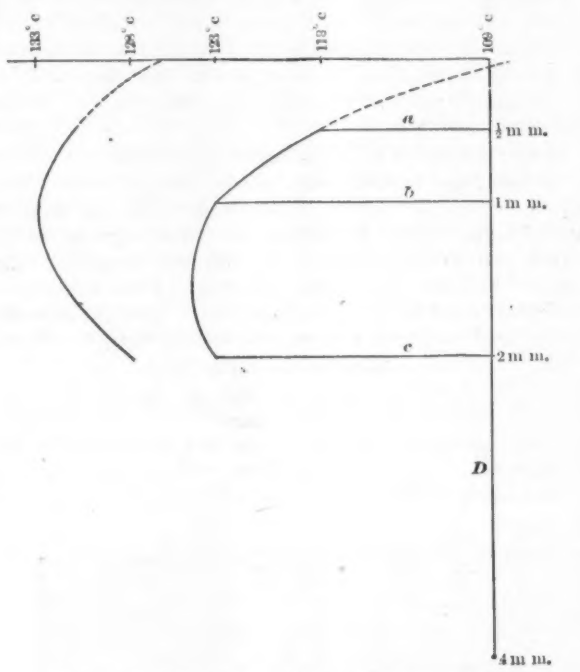


FIG. 5.—STUDY OF CYLINDER CONDENSATION.

and *n* (Fig. 4) are put in a pot of paraffine, and I go through the processes which I have indicated already.

I had three plugs like this made. With one the slice of iron was half a millimetre thick (0.051 centimetre), with the other a millimetre thick (0.101 centimetre), with the other two millimetres thick (0.203 centimetre). Let this, Fig. 2, be the indicator card from the engine with which we are making this test. I used first the plug with the thinnest slice, and I found the temperature at this depth of iron, half a millimetre, at that part of the stroke *k* (Fig. 2) just before steam is admitted. I did the same with the millimetre slice and with the two-millimetre slice. Let this line *D* Fig. 5) represent 4 millimetres of the thickness of the cylinder wall, points at depths of half a millimetre, one millimetre and two millimetres being marked upon it. Now I plot a curve. (Let me say that a part of this is prophetic; this curve I haven't been able to plot perfectly.) Suppose that distances out here to the left from the line *D* represent excesses above 109 degrees—109 degrees centigrade being the temperature of the outer surface of the cylinder wall. With the half millimetre slice at this part of the stroke *k* (Fig. 2) I find an excess above 100 degrees of 8 or 9 which I will represent by the distance *a*. With the millimetre slice I find the temperature to be greater at this part of the stroke, and I will represent the excess above 109 degrees by the distance *b*. With the two-millimetre slice the temperature was not very different from what it was with the one-millimetre. Through the tops of the lines *a*, *b* and *c* I draw a curve. (What I wish to do some time is to be able to plot a curve like that giving the temperature all the way down here inside the wall of the cylinder at this particular part of the stroke.)

I make similar determinations for that part of the stroke, *c* (Fig. 2). I find the temperature at half a millimetre depth has risen to 131 degrees more or less. The temperature at a depth of a millimetre is a little higher. This point, half a millimetre deep, has already begun to cool. The fact is, that in my engine the cut-off is like that (Fig. 2), pretty gradual, so that re-evaporation very likely begins before cut-off is complete. I suspect, however, that 131 degrees is too low for the temperature at a depth of half a millimetre. At the depth of two millimetres the temperature is not as high as it is at a depth of one millimetre. At the depth of two millimetres in the iron there is, however, a jump of some four or five degrees centigrade.

One of these curves (Fig. 5) represents the condition of this part of the stroke *k*. The other curve represents the condition of things at that part of the stroke *c*. The curves are by no means accurate, and they are very incomplete; but supposing them made perfect, I have merely to put on here a planimeter to measure the area between those two curves, and it is then easy to determine how much the heat in the cylinder at this part, *c*, of the stroke exceeds the heat in the cylinder at that part, *k*, of the stroke, and this excess of heat is the heat which has been given up by the steam to the cylinder wall, which has been done during the admission. Allowance should be made, of course, for the loss through the wall meanwhile. Then I compare that

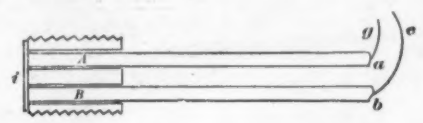


FIG. 3.—STUDY OF CYLINDER CONDENSATION.

with the indicator card and see whether the two are in agreement.

I have made some tests for points at other parts of the stroke. I found, as I have already stated, that at a half millimetre depth the temperature at cut-off has already passed the maximum, that it falls rapidly down here during expansion, and at this part of the stroke near release it is only a few degrees higher than at the end of the exhaust. But the parts deeper in the cylinder are of course slower to cool. In fact, the heat rushes into the wall here during admission; then, as soon as the pressure is relieved, the water begins to evaporate from the inner wall here and the heat ebbs back, and is spent, some part of it, in forming steam during the expansion, but not all of it; a considerable part remains at the end of the stroke, to be spent in evaporating water which is still clinging to the wall of the cylinder. As I have said, this research is by no means complete, but it has gone far enough to indicate that a very large quantity of heat goes into the cylinder wall. A very rough calculation from my experiments indicates that in the engine I am using (Kendall & Roberts' 10-inch cylinder, with 15-inch stroke) this maximum pressure I get here, Fig. 2, is about 33 pounds (above atmospheric), and I use an expansion of about 4—not quite that (about 3¼)—and about 60 strokes to the minute) according to the best estimate I can make, probably two-thirds as much steam is condensed upon the cylinder wall as remains active at the beginning of expansion. I should say that two-fifths (this is very likely an over-estimate, perhaps one-third would be safer) probably of all the steam that enters that cylinder is condensed upon the cylinder wall upon the first quarter of the stroke. How much of that is re-evaporated during the stroke and so helps, more or less, I do not yet know. According to the indicator cards taken during the experiments with the plugs, the weight of steam in the cylinder at the end of expansion is about 1.25 times as great as just after cut-off. How much heat is absorbed by the layer of water which remains over from the previous stroke I cannot tell. I think there is some evidence that a layer of water does remain over from the previous stroke. This examination shows, however, that the iron is exceedingly effective in cylinder condensation, and it suggests the question whether it is not possible to coat the inner wall of the engine with some-

FIG. 4.—STUDY OF CYLINDER CONDENSATION.

thing which would prevent, to a considerable extent, this condensation. It is not easy to find something with which one can coat the rubbing surfaces of the cylinder, I suppose, but there is the end of the cylinder and there is the face of the piston, and those two surfaces make, in the case of a short cut-off, perhaps more than half the area which is effective in this cylinder condensation. It doesn't seem to me at all impossible that some comparatively non-conducting material can be found with which those surfaces can be coated so as very materially to decrease the cylinder condensation. Experiments for that purpose could easily be made with plugs of this kind. Instead of having to coat the whole cylinder, one might lay on this plug some non-conducting material, and see how much difference that would make in the amount of heat absorbed. I haven't attempted anything of the kind, but it doesn't seem fanciful to imagine that something valuable might come out of it, and a very large saving in the steam used in steam engines might perhaps be made in this way.

The research of which I have here given an account has been carried on with money from the Rumford fund of the American Academy of Arts and Sciences.

For indispensable assistance in the investigation I am indebted to Messrs. Barron, Curtis, Hale, Kendrick and Page, members of a class at Harvard College engaged in a study of the steam engine.

* In my latest experiments the fly-wheel has made about 60 revolutions per minute, and contact has lasted about $\frac{1}{10}$ part of a revolution. The cam pushes two pieces of brass together without touching either of them directly. Springs hold the two slips of brass apart when the cam is not acting.

† In some of the experiments this joint was not perfectly tight, for *water* was sometimes seen to come out by the *core N* before the plug became hot. Generally upon such occasions the leaking appeared to cease when the plug became hot. The fact probably is that the joint continued to leak slightly, but leaked *dry* steam, the temperature at the outer end of the plug being about 100 degrees C. and at the inner end considerably higher. Both experiment and reason indicate that the effect of such leakage upon the temperature found was slight.

* The nickel used was of fair commercial quality. I am not yet prepared to publish details of the measurement of its conductivity.

The New Westinghouse Compound Engine Governor.

After two years of invention and experiment, the Westinghouse Machine Company, of Pittsburgh, Pa., has designed a governor for use with its high-duty compound engine, whose efficiency, it is claimed, has never been equaled. With its accustomed disregard of established practice, this company has had the same marked success with its governor as with its engine.

Sectional views of the governor, as in Fig. 1, show at once its simplicity, and an absence of all the usual attachments of dash-pot, balanced eccentric, interlocking devices, etc.

It will be interesting to note the details of its construction. A heavy unbalanced eccentric and strap places the centre of gravity of the combination very near the centre of the shaft without sacrificing its strength. Short, heavy springs with low initial tension are available in this form, and the governor is so compact that it is placed in a heavy closed case, which is completely filled with oil to insure certain and copious lubrication.

While the governor, as a whole, is very heavy and perfectly free to move, even through its whole range if necessary, its strength is a variable quantity, and its leverage increases so as to meet and resist the greater strains of longer cut-offs. The chief excellence of the governor, however, is its ability to utilize its inertia for the necessarily rapid adjustment to meet instantaneous changes of load. The mere tendency of the engine to change its speed to the degree demanded by the regulation on account of change of load, throws the governor to the new position to suit such new load, and the force that changes the adjustment of the governor is inertia.

A test, so severe that it would be but seldom met with in practice, was made on an 18-inch and 30 × 16-inch Westinghouse engine with this form of governor at the station of the Federal Street and Pleasant Valley Electric Railway Company in Allegheny City, Pa., and fac-similes of the indicator cards are given as evidence of the rapidity of the governor's action.

Four circuits are driven by this engine, and in the card shown in Fig. 2 one of these was broken while a continuous card was taken from the high-pressure cylinder.

The card shown in Fig. 3 was similarly taken while three of the four circuits were broken at the same time, and shows an average change of 87 h. p. per second. It also shows that the governor was perfectly stable in its new position. At this rate, the governor would travel over its entire range, corresponding to a change of its listed capacity of 250 h. p., in less than three seconds, which is about the time necessary to increase the speed of the engine the amount demanded by the regulation, and with a lighter fly-wheel this change would be made in proportionately less time.

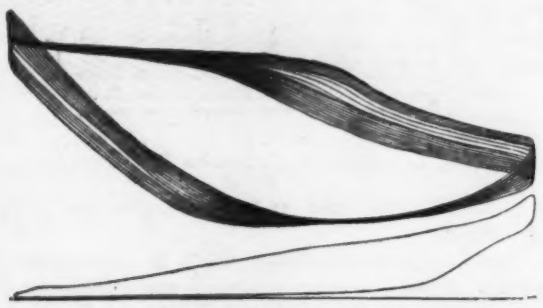


FIG. 2.—WESTINGHOUSE ENGINE CARD.

Electric Light for Transporting Plants.

By the aid of the electric light the Botanical Mission dispatched some months since by the authorities of Kew to the West Indies were extricated from an embarrassing dilemma. They had with them a number of Wardian cases containing vine cuttings and Gambier plants, which it was deemed very desirable to introduce into the islands; but, unfortunately, cold weather set in, and the efforts to convey these tender plants, which had so often ended in failure, threatened once more to result in disappointment. The difficulty was that if kept on deck they would be inevitably destroyed by the low temperature; while if taken below the absence of light, which is so necessary to the existence of the delicate Gambier plants, was almost certain to be equally fatal. Under these circumstances it occurred to Mr. Morris to avail himself of the electric light, of which there was an abundance aboard the Atrato. The experiment proved in every way successful. Mr. Morris expresses the opinion that the use of the electric light for the safe passage of valuable plants during the winter months is capable of being greatly extended.

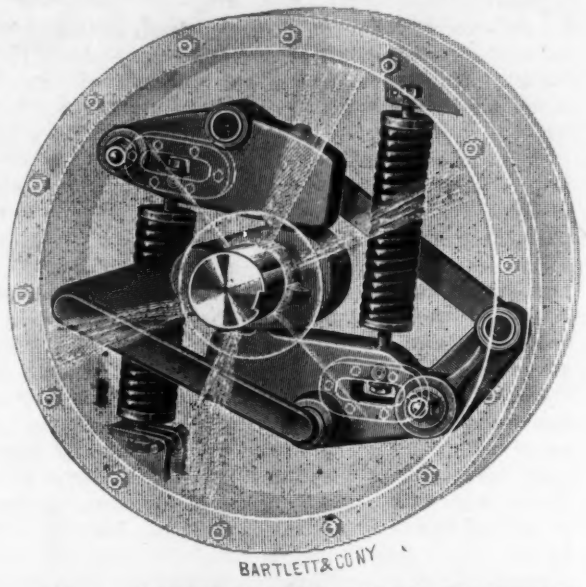


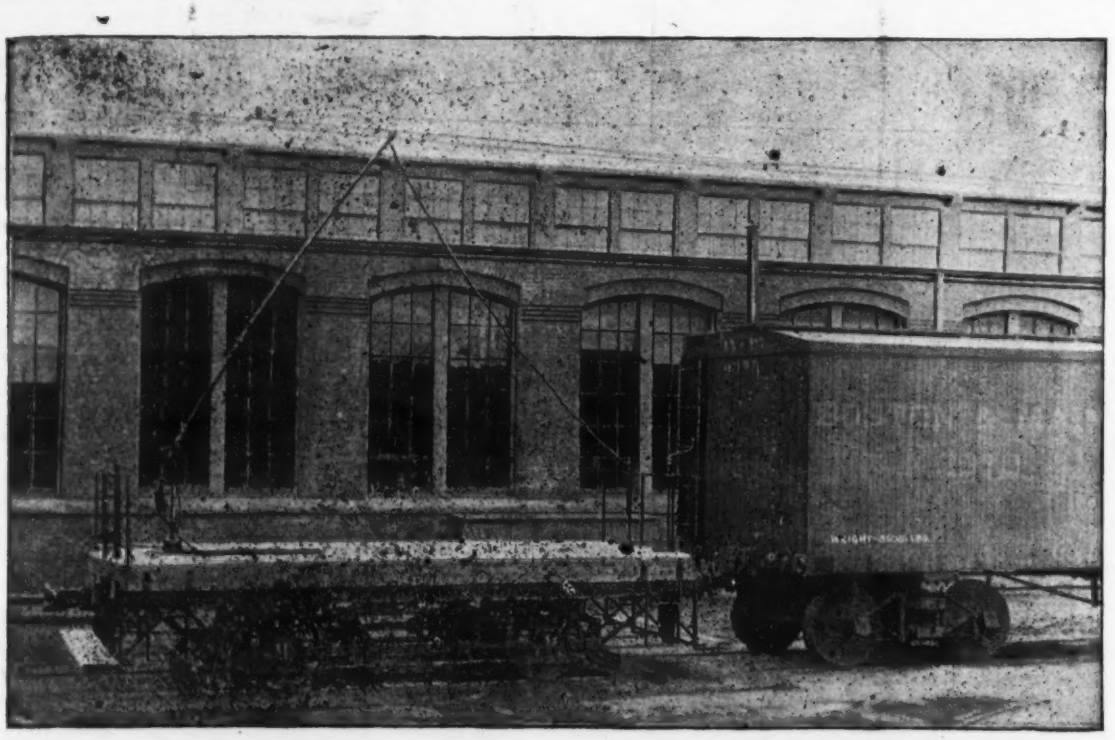
FIG. 1.—WESTINGHOUSE ENGINE GOVERNOR.

An Electric Freight Car.

The accompanying cut serves not only to illustrate the apparatus, but in addition proves that almost every day sees the production of some new type of electrical machinery adapted to mill work. The handling of both raw material and finished products of a mill is now rendered an easy matter by the use of the electric current. There are but few of the large mills that have not sufficient surplus power to operate an electric generator, the current from which, by the aid of electric motors, can be made to do certain classes of work much more satisfactorily and economically than can be accomplished in any other way.

The apparatus illustrated is one of the largest freight locomotives which has been constructed to operate by means of electricity. It was built by the Thomson-Houston Motor Company, of Boston, and is now in use at the cotton mills of the Lonsdale Company at Lonsdale, R. I. As can be seen from the illustration, the locomotive consists of a platform car and truck equipped with a 30 h. p. Thomson-Houston motor. It is provided with a trolley stand and trolley at one end, and at each end with a controller stand, by means of which the speed of the locomotive can be governed and its direction changed when necessary. The locomotive is capable of hauling a load of 60,000 pounds at the rate of five miles an hour. In addition to its use for haulage purposes, the locomotive platform, which measures 8 × 18 feet, may be loaded with material which it is desired to transport from place to place.

The total length of track over which the locomotive is used is 2,700 feet, on which the single overhead trolley system has been used, the wire being suspended over the center of the track by means of brackets fastened to the buildings where possible and to poles. The conductor varies in height from the ground between 16 and 18 feet. The necessary electric current for the operation of this tramway is obtained from a 500-volt Thomson-Houston dynamo of 30,000 watts capacity, which is driven from one of the water wheels which furnish power for the mill machinery.



THOMSON-HOUSTON ELECTRIC FREIGHT TRAMWAY SYSTEM.

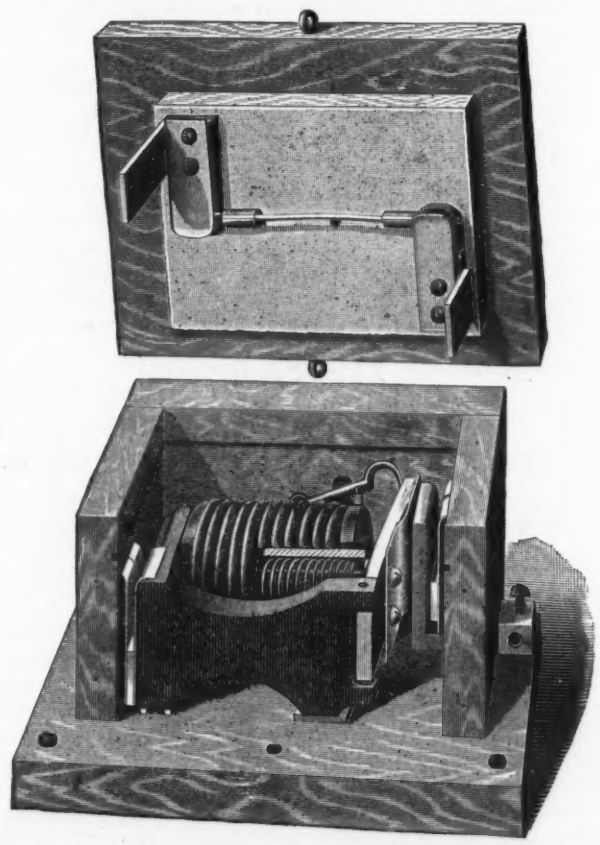
A Magnetic Cut-Out for Railways.

There is quite a demand for a reliable safety device which will open the circuit on street railway lines when the current exceeds a certain amount. A simple fuse is not to be relied on in all cases, but by combining a magnet and a fuse we get a cut-out which will give a more positive protection to the circuit.

This is done in the magnetic cut-out designed by Mr. W. E. Harrington, and built by George Cutter, of Chicago. As the cut shows, a properly proportioned magnet is placed in shunt with a fuse which can carry but a small part of the maximum safe current. The resistance of the magnet being low, the fuse is practically shunted out until the current through the magnet becomes too great. Then the armature is drawn up, and the whole current is sent through the small fuse, which is sure to blow. A spring catch holds the armature until the fuse is replaced, which can be quickly done without the use of any tools.

The magnet is protected from the molten metal by a thick sheet of asbestos, and all parts are made of ample size. The whole apparatus is well built and has been tried with much success.

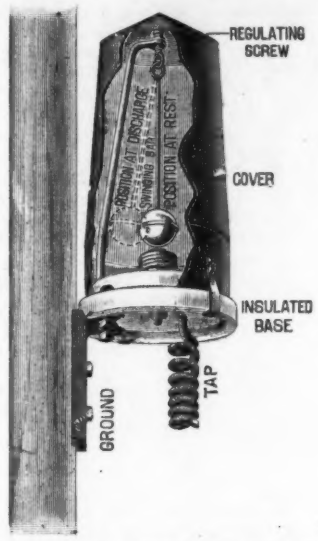
It is a matter of considerable importance to electric railway managers that the lines should be carefully equipped with apparatus which will fully protect them from the possibility of carrying for any length of time an amount of current that may prove dangerous to the armatures of the machines.



STREET RAILWAY CUT-OUT.

The Swinging Ball Lightning Arrester.

Some time ago it was discovered that the well-known expansive effect of a disruptive discharge or arc mentioned by Francis in the description of his electric popgun was applicable to the eliminating of the bad effects of lightning discharges through the circuits of electric light and power plants. One of the neat lightning arresters utilizing the above-mentioned effect is the "swinging ball" arrester manufactured by Messrs. Truex & Vail, of New York City. It is an ingenious piece of apparatus. A static charge from the line passes to earth through the pendulum arm, across the space between the ball, or "bob," and the ground plate below it and in close proximity thereto. If a tendency occurs for the flow across this space of the dyna-



SWINGING BALL LIGHTNING ARRESTER.

mo current a heavy arc is formed between the pendulum ball and the plate below, and the sudden expansion of the air causes the pendulum to swing aside, thus breaking the arc. The arm then swings back into position, and the arrester is ready for work again. It is claimed that this apparatus suffers very little from deterioration.

The Lahmeyer Current Transformer.

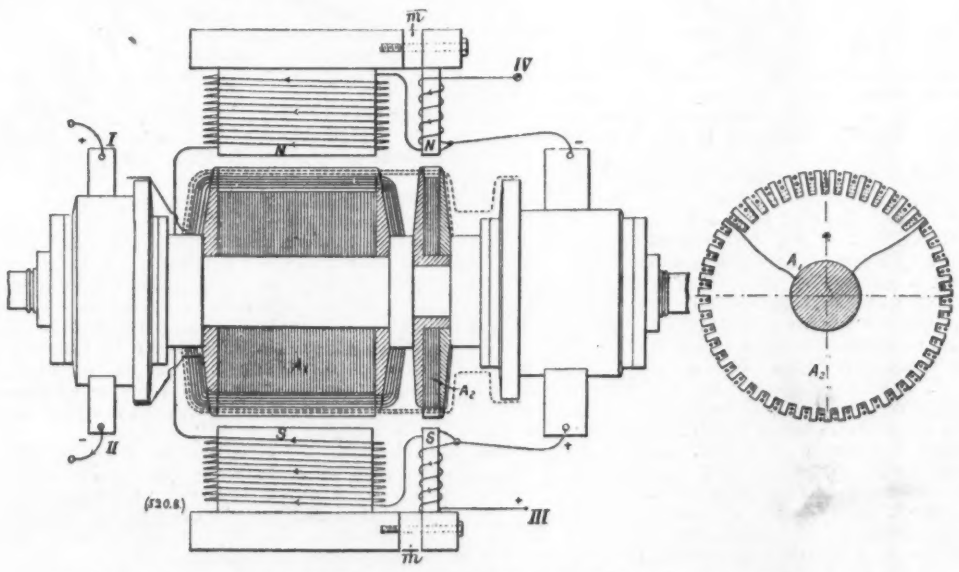
To convert high-tension continuous current into low-tension one method is to drive by means of a high-tension motor a low-tension compound dynamo. Such combinations are built by Deprez, Schuckert and others, and are termed by them motor dynamos. A simpler method for transforming currents consists in having only one armature, wound, however, both for the high-tension supply and the low-tension resultant current. This form of current transformer with but one magnet field is a construction of high practical value; the cost is smaller, the efficiency higher and the result in regard to sparkling more satisfactory than in the motor dynamo. Its only drawback is that it has not perfect regulation, or that amount of compounding which, given a constant primary electromotive force, supplies a secondary electromotive force irrespective of the load. The primary and secondary windings of the magnet require to be arranged to give opposite polarities; the transformer cannot therefore be regulated by simply altering the magnetism.

Referring to the illustrations on this page, for which, with this description, we are indebted to *Engineering*, Fig. 1 shows the external appearance of the Lahmeyer current transformer, while Figs. 2 and 3 show the details of construction. This apparatus is now being exhibited at Frankfort. From the branches I., II., the high-tension current flows to the armature coil, wound upon the main armature A_1, while the secondary coil, besides surrounding the armature A. also passes round the armature A_2. Acting upon this latter is a field magnet III., IV., upon which circulates the secondary main current. The current in this coil is proportionate to the difference of current of the armature A^1; the additional electromotive force of the armature A_2 is also proportional to it. Without adding any special commutator or any parts liable to wear or requiring special attention, the compounding of this transformer is thus accomplished. The compound magnetic field is separated from the main field by an insulation of brass, *M*, *N*. The armature A_2 and the field magnet belonging to it are thus separated from the main magnet. The dimensions of these latter have to be increased so as to obtain the necessary tension without *A* and its magnet frame. For tensions up to 600 volts and small sizes Mr. Lahmeyer constructs his transformer with drum armatures, placing, as shown in Fig. 3, the two armature coils, with an insulated division, above one another. In the case of larger patterns Mr. Lahmeyer uses the Gramme ring form for both armatures; the coils are in this case side by side, each bobbin in a separate groove. The grooves are covered with a thick layer of fiber insulation, and each bobbin is singly accessible and exchangeable.

It will be remembered that in motor dynamos with two armatures on the same shaft the insulation of the two coils from each other is only formed by the covering around the armature cores: since it is not mechanically convenient to introduce a non-metallic part it will be admitted that even in respect of accessibility and mechanical security nothing has been sacrificed.

Compared to the motor dynamos a transformer of this construction has the advantage of reduced size and cost. According to Mr. Lahmeyer's statements, the efficiency of these transformers is the same as that of dynamos of the same size, and with equal excitation the transformer works with a higher degree of magnetic saturation, because the reactions of the armature coils balance each other; it is, moreover, well known that this latter condition obviates sparking. The efficiency of large transformers may, therefore, be taken as 92 per cent., a saving of 8 per cent. over motor dynamos, which is of considerable importance, particularly in long lines. The attendance required is less for the transformer than the motor dynamo, owing to absence of any appreciable influence of heating of the wires upon the tension of the current. This transformer offers, hence, the simplest means of distributing continuous currents over large districts. Where accumulators are used Mr. Lahmeyer constructs the regulator frame of the larger dimensions, and provides, besides the direct, an auxiliary terminal winding or coil. When charging the accumulators both coils are switched in, thus causing additional electromotive force; for working in parallel circuit only the one is used. A change of polarity in the transformer cannot take place.

This transformer can be directly connected over long distances with a source of high tension without requiring any other means for regulating the tension, which materially simplifies the arrangement of a large current distribution, thus obtaining all that can be expected for continuous currents.



FIGS. 2 AND 3.—LAHMEYER CONSTANT CURRENT TRANSFORMER.

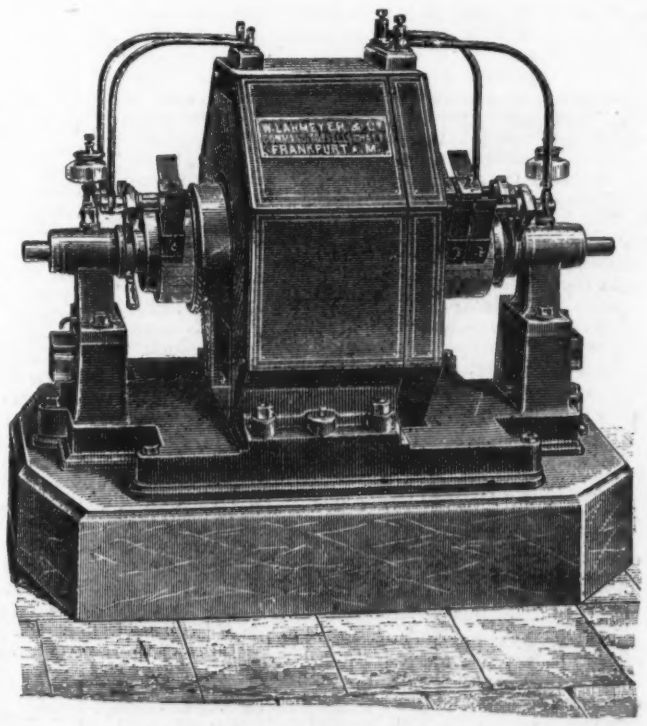


FIG. 1.—LAHMEYER CONSTANT CURRENT TRANSFORMER.

Memorandum on the Preparation of the Clark Standard Cell.

The following memorandum has been drawn up for the consideration of the Electrical Standards Committee of the Board of Trade in London:

DEFINITION OF THE CELL.

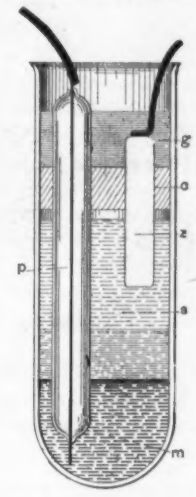
The cell consists of zinc and mercury in a satuiated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess, and is conveniently contained in a cylindrical glass vessel.

PREPARATION OF THE MATERIALS.

1. *The Mercury.*—To secure purity it should be first treated with acid in the usual manner, and subsequently distilled in vacuo.

2. *The Zinc.*—Take a portion of a rod of pure zinc, solder to one end a piece of copper wire, clean the whole with glass paper, carefully removing any loose pieces of the zinc. Just before making up the cell dip the zinc into dilute sulphuric acid, wash with distilled water and dry with a clean cloth or filter paper.

3. *The Zinc Sulphate Solution.*—Prepare a saturated solution of pure ("pure recrystallized") zinc sulphate by mixing in a flask distilled water with about twice its weight of crystals of pure zinc sulphate, and adding a little zinc carbonate to neutralize any free acid. The whole of the crystals should be dissolved with the aid of gentle heat, and the solution filtered, while still warm, into a stock bottle. Crystals will form as it cools, and when the solution is to be used a little should be taken from the bottom of the bottle near the crystals with a pipette. While this is being done the liquid should be at a decidedly



STANDARD CELL.

g, marine glue; *c*, cork; *z*, zinc; *p*, platinum wire; *s*, paste; *m*, mercury.

higher temperature than that at which the cells will ordinarily be used.

4. *The Mercurous Sulphate.*—Take mercurous sulphate, purchased as pure, and wash it with distilled water. Drain off as much of the water as possible. Mix the washed mercurous sulphate in a mortar with the zinc sulphate solution, adding sufficient crystals of zinc sulphate from the stock bottle to insure saturation, and a small quantity of pure mercury. Mix these well together to form a paste of the consistence of cream, and then heat the paste sufficiently to dissolve the crystals, afterward allowing the mixture to cool, and thus to form a saturated solution of mercurous sulphate in a saturated solution of zinc sulphate.* The presence of the free mercury throughout the paste preserves the basicity of the salt, and is of the utmost importance.

Contact is made with the mercury by means of a platinum wire about No. 22 gauge. This is protected from contact with the other materials of the cell by being sealed into a glass tube. The ends of the wire project from the ends of the tube; to one end a piece of copper wire is soldered; the other end and a portion of the glass tube dip into the mercury.

TO SET UP THE CELL.

The cell may conveniently be set up in a small test tube of about 2 centimetres diameter and 6 or 7 centimetres deep. Place the mercury in the bottom of this tube, filling it to a depth of, say, 1.5 centimetres. Cut a cork about .5 centimetres thick to fit the tube; at one side of the cork bore a hole through which the zinc rod can pass tightly; at the other side bore another hole for the glass tube

*If the saturated solution of zinc sulphate is not heated the cells do not usually agree with each other until some time after they have been set up. If the above method is followed the agreement is good at the time of setting up, and should be very close indeed after a day's rest. Care, however, must be taken that the paste is not supersaturated when cold.

which covers the platinum wire; at the edge of the cork cut a nick through which the air can pass when the cork is pushed into the tube. Pass the zinc rod about one centimetre through the cork.

Clean the glass tube and platinum wire carefully, then heat the exposed end of the platinum red hot, and insert it in the mercury in the test tube, taking care that the whole of the exposed platinum is covered.

Shake up the paste and introduce it without contact with the upper part of the walls of the test tube, filling the tube above the mercury to a depth of rather more than two centimetres.*

Then insert the cork and zinc rod, passing the glass tube through the hole prepared for it. Push the cork gently down until its lower surface is nearly in contact with the liquid. The air will thus be nearly all expelled, and the cell will be ready for sealing.

Melt some marine glue until it is fluid enough to pour by its own weight, and pour it into the test tube above the cork, using sufficient to cover completely the zinc and soldering. The glass tube should project above the top of the marine glue.

The cell thus set up may be mounted in any desirable manner. It is convenient to arrange the mounting so that the cell may be immersed in a water bath up to the level of, say, the upper surface of the cork. Its temperature can then be determined more accurately than is possible when the cell is in air.

The accompanying figure, which does not form part of the memorandum, has been prepared in accordance with the particulars given therein, and is reproduced from *The Electrician*, London.

The Incandescent Lamp Patent Case.

CIRCUIT COURT OF THE UNITED STATES—SOUTHERN DISTRICT OF NEW YORK. IN EQUITY.

THE EDISON ELECTRIC LIGHT COMPANY	Before
vs.	Hon. W. J. WALLACE,
THE UNITED STATES ELECTRIC LIGHTING COMPANY.	Circuit Judge.

ARGUMENT ON FINAL HEARING.

ABSTRACT OF THE ARGUMENT OF SAMUEL A. DUNCAN, ESQ., FOR DEFENDANT.

It may be of some value to get a clear apprehension of what the problem was that Mr. Edison undertook to solve in connection with electric lighting. Was the problem which he set before himself the invention of a lamp, or was it a broader problem of a much more complex nature, calling for invention not in one direction, but, if you please, in a hundred? The bill of complaint tells us something in regard to this. Mr. Edison addressed himself to work at Menlo Park with a view to inventing "a complete system of electric lighting by incandescence, which should be capable of competing with other forms of illumination and adaptable to general use." The bill declares that the invention of such a system "necessitated the perfection of several distinct apparatus, such as machines for generating the electricity, conductors for conveying it to the translating devices, instruments for regulating automatically and otherwise the pressure and quantity of the current, meters for measuring and recording its consumption, lamps for converting it into lights, sockets and holders for supporting the lamps, with many other devices and things necessary to be used in such a system, each machine, apparatus, part being perfected only after many experiments, and frequently embodying distinct and separate inventions."

The result of Mr. Edison's work—for he was early in the field, after the great impulse that came in the domain of applied electricity with the perfection of the dynamo machine, whereby a current could be economically generated; I say he was early in the field, backed by a powerful syndicate furnishing him with all the money that was necessary for working his expensive laboratory—the result of his labors in the solution of this complex problem, to wit, the development of a system of electric lighting, is found in the large number of patents that have been issued to him from time to time. There was a circular issued by the Edison Company, for instance, in November, 1882, in which it was stated that Mr. Edison had at that date secured not less than 150 patents on his various inventions relating to this system on which he had been at work, and many others followed in subsequent years. We find early in the career of the Edison Company, in the year 1883, that they were attaching to the packages containing the lamps that they sent out to their customers labels which professed to indicate the various patents relating to lamps and to the manufacture of lamps under which the company was then licensed, being 121 patents in number at that date. Mr. Edison's own account of what he undertook to do is expressed in the following language:

"The problem, then, that I undertook to solve, stated generally the production of a multifarious apparatus, methods and devices, each adapted for use with every other, and all forming a comprehensive system whereby electricity, properly controlled and directed, could be distributed over large areas through the streets of a city, and supply to houses in which it would feed incandescent electric lamps of moderate candle power, which would be entirely under the control of the household, the whole to be on the same scale as the present system of gas distribution and affording the same character of convenience to the users."

I trust that your Honor will not overlook the fact that there were other inventors at work upon this general problem contemporaneously with Mr. Edison, and who were as early in the field as he. The gentlemen associated with the United States Electric Lighting Company, the defendant in this suit, were early in the field. The United States Electric Lighting Company had a commercial plant in operation in the city of New York as early as November, 1880, by which they were supplying not a very large number of customers, for it was not a large plant, but yet it was a central station plant, and I believe was the first central station plant for incandescent electric lighting organized in this country. I think I am correct in saying that so far as this record shows no lamps were sold by the Edison company until after the organization of that central station plant by the defendant's coöperation. And I think I am right in saying that the record shows that no lamps were sold by the Edison company during the year 1880. There was one experimental plant put in operation by the Edison company on the steamship Columbia, which sailed around to California, and that I believe was the first electric lighting plant that was put out by the Edison company; but it does not appear that that was anything more than an experimental plant, and put in without compensation.

Before examining the prior state of the art, in order to determine the real nature of the invention disclosed in this patent in suit, I desire to call the attention of the court to one expression found in the patent. The patent says (I read from the Patent Office copy) in the first column of the first page, line 44: "In general, the attempts of previous persons have been to reduce the resistance of the carbon rod." This can mean but one thing, viz., that previous experimenters (if you please to apply that term to those that went before—"previous manufacturers of lamps" is the expression I prefer) undertook to reduce the specific resistance of the carbon which they employed as the burner of the lamp and not the total resistance. It seems to me important that that distinction shall be kept sharply in mind throughout the whole discussion. The difference between specific and total resistance is this: "If we take a given volume of mercury and an equal volume in the same form of carbon, or of platinum—if we take, for instance, a cubic inch—we shall find that the electric current will go through the mercury much easier than it will through the platinum or the carbon. The platinum will occupy a stage immediately between the mercury and the carbon. In other words, the mercury opposed less resistance to the flow of the current than either of the others; or, to put it in another way, its conductivity is greater. That is what we mean by specific resistance. It is the relative resistances of different bodies. The specific resistance of carbon is greater than that of platinum. The specific resistance of platinum is greater than that of mercury. And this is simply because a given volume of carbon, as in a cubic inch, will conduct the current better than a cubic inch of platinum—it will oppose more resistance to the current than a cubic inch of platinum. Now it was true in the prior state of the art that those men who use carbon for the pencils of an arc lamp, or for the continuous conductor or burner of an incandescent lamp, used a greater carbon which had comparatively low specific resistance. Carbons differ among themselves in that regard. You can take a carbon and treat it in such way that it will have a very high specific resistance; you can take it in such a way that it will have a comparatively low specific resistance, although all of the carbons have a high specific resistance as compared with platinum or mercury.

High total resistance is a desirable thing, and has always been known as a desirable thing, for the burner of an incandescent lamp, whether that lamp was to be used by itself, a single one on a circuit, or was to be used in series, or was to be used in multiple arc. There is no mystery about that. The whole principle underlying the incandescent lamp is that you have a continuous circuit (in which respect it differs from the arc lamp) through which the current flows; and if you will make one part of that circuit of higher resistance than the other parts you will develop more heat at that point; and the higher you make that part of the structure relatively to the other parts the more heat you will develop and the more light you will get.

When we come to apply this established rule, that high total resistance is desirable whether your lamp be used as one by itself, or there are a number in series, or a number in multiple arc, we find certain limitations imposed upon us and in this way: I have here a little diagram which shows the dynamo machine and a circuit with four lamps arranged in series. Suppose that each one of those lamps has a resistance of 100 ohms. It will take a current of a certain electromotive force to overcome the resistance of one of them if it were there by itself. If we put another lamp in the same circuit we have got to increase our electromotive force. And so on as we advance—until very soon we shall get up to that point when we cannot add any more lamps because it would necessitate a current of such high electromotive force that it would be a dangerous current to handle. If we were going to put a very few lamps in a circuit, arranging them in series, we would make the resistance of each one of them much higher than if we were to put a large number in series. If, for instance, we would employ safely (and we can) a current of 1,000 volts, then we could put 100 lamps in series having each a resistance of but 10 ohms; but if we were to carry the resistance of our lamps up to 100 ohms, then we could put in but 10 of those lamps. It is a desirable thing; it will be economical to employ the high resistance lamps even in series; and we should therefore, in conformity with the well-known laws of electrical distribution—known long before Mr. Edison ever undertook the solution of this problem—we should, if we had been working in that direction, have carried the resistance up just as high as was practicable consistently with the condition by which we are bound.

I come now to consider what there is in the prior state of the art for the purpose of determining the position which Mr. Edison occupies, so far as concerns the inventions covered by the patents in suit.

It is only thus of course that we can determine what the real invention is to which the claim of the patent relates. Of course it is desirable to ascertain what Mr. Edison's date of invention was. I do not know that your Honor will have any difficulty in drawing from the remarks of the counsel who opened for plaintiff the inference that Mr. Edison made the invention to which the patent in suit relates on the 21st of October, 1879. His own testimony seems to be very explicit on that point, for I assume that his invention is not broadly for putting a carbon burner into a high vacuum. Possibly that will be asserted, for it is in the closing argument; but that feature was very old in the art. Nor is his invention for putting a very thin and slender burner in a high vacuum independent of the material out of which the burner was made; for that I say was also old in art. It was old with Mr. Edison himself. It was also old to put carbon when brought into a thin and slender form into a high vacuum. But the question is, When did Mr. Edison invent the incandescent lamp which depends for its virtue upon that peculiar form of carbon to which he has given the undefined and undefinable name of "filament"? Whatever he may have done with the carbon in other forms than the filamentary form, or whatever he may have done with other substances than carbon when reduced to filamentary forms, is wholly immaterial to the present question—which is, When did Mr. Edison make an incandescent lamp into which he introduced carbon brought into that form which he had given the name of carbon? That he did not before the 21st day of October, 1879—his testimony upon that point is found in vol. IV., page 2,557. He says:

"If I remember right, it was on the 21st of October, 1879, that God's sunlight was thrown on this business of incandescent lighting."

That was a revelation to him—a kind of a St. Paul business!

I come now to consider briefly as may be Crookes' radiometers. Prof. Crookes published a series of articles describing these radiometers in the *Philosophical Transactions* of the Royal Society at London away back in 1874, 1875, and running until 1878, in which he gave a most interesting account of some experiments which he had been carrying on in connection with investigations of radiant matter, etc. Among the apparatus which was described by him was the instrument known as a radiometer.

Mr. Crookes by the use of the Sprengel pump produced a vacuum very much in excess of any of the vacua that are used in incandescent lamps of the present day. He passed a current through leading wires sealed through the glass to the platinum spiral and brought that up to a vivid incandescence. That was an incandescent lamp in which the leading-in wires were made of fine platinum wire, and they were sealed into the walls of the lamp by the fusion of the glass directly upon the wires. The air was exhausted from that glass receiver. Thus we have created an apparatus which gives the Edison lamp of the patent in suit with the exception that we have not got, so far as I know, the carbon filament. I do not know what the carbon filament is, but we have not got the carbon filament here because we have not got the carbon, and I suppose we cannot have a carbon filament unless there is some carbon about it. Perhaps Brother Lowrie can enlighten us upon that point, but I suppose he will not do so until it will suit his purpose to do so. But we have here the platinum spiral; and we have here what is a thread of light platinum, if that be a definition of a filament; but we certainly have not the carbon here. I have not one of Crookes' radiometers in that particular form, but there is another form of Crookes' radiometer, described in the testimony and referred to in the brief, and I have here a specimen of it. It is not in evidence. At the two sides here the platinum wires enter, and then they connect inside with a very fine platinum ring or loop of wire. In that case, as in the one we have just examined, the current being passed through the walls of glass where the seal takes place meets the high-resistance little platinum loop inside, and brings that up to incandescence. You have there the high vacuum, you have the all-glass globe, you have the fine platinum leading-in wires, and you have the burner inside. Now, that was a lamp. It was not a lamp intended for general illumination. That was not Mr. Crookes' object at all. It was a lamp designed for certain special uses, namely, to light up and throw bright rays upon the little faces of that apparatus inside, in order to produce upon those certain physical effects which he desired to investigate. It was a lamp for a special use, but it embodied in its construction many of the principles which Mr. Edison professes to have discovered and embodied in his lamp which he devised for the general purposes of illumination.

I need not review the teachings of these radiometers in regard to those things that were old in the art in their bearing upon the patent in suit. I desire, however, in this connection to call the attention of the court to the record in Freeman's application for a patent found in vol. IV., page 2,530. In the year 1881 Mr. Freeman filed an application in the Patent Office in which he showed incandescent lamps having a carbon burner enclosed in an all-glass globe, highly exhausted, with platinum leading in wires; and he made the claims which were supposed to cover pretty nearly the same ground as the claims in some of Mr. Edison's patents. He was put into interference with Mr. Edison—with this very patent of Mr. Edison's. He had cited against him as one of the references King's English patent, about which we have already heard; and he amended his claim in view of the King patent so as to read as follows (page 2,536):

"An electric lamp for giving light by incandescence, consisting of a strip or filament of carbon of high resistance enclosed within an exhausted receiver made entirely of glass and attached to metal wires passing through and sealed into the glass as set forth."

I say that an interference was declared between him and Mr. Edison, and at some time subsequent thereto the interference was suspended by the Commissioner of Patents in order that this radiometer of Mr. Crookes might be cited as a reference. On page 2,540 is the next Patent Office communication, in which the office says:

"In view of a newly discovered reference found in the Philosophical Transactions for 1876, page 351, and 1874, page 513"—being a form of radiometer to which I first called attention—"the above-named application has been suspended from interference in order that it may be rejected.

"It is not deemed material that applicant claims a carbon filament in place of a platinum conductor shown in the reference, the substitution of one for the other being a matter within the skill of one well versed in matters pertaining to electric lighting, it being old in the art to use carbon conductors for incandescing lamps."

From that a re-examination and reconsideration of the matter was requested by his attorney in charge, and that re-examination was given and the action of the office was reaffirmed, constituting the final action and rejection. Apparently this publication of Mr. Crookes was not known to the Patent Office at the time that Mr. Edison's patent was allowed. Certainly they would be as pertinent against Mr. Edison's application as against Mr. Freeman's.

Coming down to the year 1879, we have a patent granted to Moses G. Farmer (vol. VI, page 4,628), which is of no special value in this action, except that Farmer proposes to use carbon as the burner of his incandescent lamp, and that carbon is to be wrought into the form of a small pencil or thin bar.

The next important thing in this connection is the Edison platinum lamp. At some early date in the year 1879 Mr. Edison produced a platinum lamp which was strikingly like the carbon lamp of the present patent. He made an application for a patent for this platinum lamp in the

* When the cell has been set up for a little time the more solid portion of the paste sinks to the bottom, leaving clear liquid above.

United States in April, 1879, and almost contemporaneously made an application for a foreign patent on the same invention. Some of the foreign patents were issued in advance of the American patent. His French patent was issued in June, 1879, and the Italian patent at about the same time. His American patent did not issue until May 4, 1880, and therefore was later than the patent in suit. But the invention which is described in the American patent had entered into the art before the making of the invention of the patent in suit. It had entered into the art because it had been described in newspapers, and it had become crystallized in the foreign patents. It was in the Patent Office of the United States as the subject matter of a pending application, and if not know to the world at large as there, it was to Mr. Edison at any rate a part of the prior state of the art. It is to the consideration of that patent and the relation which it sustains to the patent in suit that I now invite your Honor's attention. For greater convenience I will hand to your Honor a copy of the foreign patent.

The COURT: Do I understand you to say that this invention has been described in any publication in this country?

Mr. DUNCAN: Yes; and it had been described in the French patent of June, 1879, and in the Italian patent of about that date; so that for convenience only I refer to the American patent just the same as if it had been issued prior to the date of the patent in suit. The French and Italian patents were actually issued in June—not simply dated back—but they were before the world as an open document in that month. The French patent is found in vol. IV., p. 2,479.

There is fully set forth the relation which exists between the size and proportion of the burner of an incandescent lamp and the amount of material necessary to be used in the outside circuit for conveying the current to the lamp. What is true in relation to a lamp having a metallic burner is equally true, and none the less true, in relation to a lamp having a carbon burner, and whenever Mr. Edison, and whenever Mr. Lane-Fox, and whenever anybody preceding them, announced that principle to the world, there was no invention in subsequently applying that principle in the case of lamps in which a different material happened to be employed for a burner. That is a question of electrical engineering, and has not any relation to the peculiar construction of a lamp: that is, to the material out of which the lamp is to be made.

Mr. Edison gives a piece of testimony which I find quoted in plaintiff's brief in another connection bearing upon this question of the relation between this peculiar problem and the character of the burner. At page 3,013 of Vol. V. Mr. Edison says:

"The great point we desired was a lamp of high resistance and small radiating surface, and it did not matter very much whether it was of carbon or of platinum."

That is a distinct recognition by him that this principle, this great discovery, this thing which our friends tell us lies at the very foundation of the patent in suit, was a principle having an application just as much to a platinum lamp as to a carbon lamp. And that principle is emphatically and elaborately announced by Mr. Edison in earlier platinum lamp patents which had entered into and become a part of the prior state of the art. I understood the gentlemen who opened for the plaintiff to put that forth as the great distinguishing feature of Mr. Edison's invention,—that he was the first man to "appreciate"—that was the word that he used, not once only, but a dozen times. They did not say even to "discover"; but they say that he was the first man to "appreciate" at its full value the relation that high resistance joined with small radiating surface sustains to economy of the copper in the conducting wires of the circuit. Therefore (that is the argument, as I caught it), the patent in suit is to be sustained with a broad interpretation. We say in part, not alone but in part, upon the strength of Mr. Edison's own patents for completed inventions taken out before he had made the invention of the patent in suit, that that principle was old in the art. He knew it. He had revealed it to the world himself—perhaps supposing that he was the discoverer of it. He had given it to the world through various patents long before he made that invention which alone can be found in the patents in suit—months before the "great flood of sunlight came in upon the art of incandescent lighting" (to borrow his expression) he himself had taken a patent on this thing, not simply described, but had taken a patent for it; for that I understand to be the substance of some of these claims patenting this very thing.

I suppose that we may be met with the question whether this platinum lamp has ever gone into extensive use; whether it is a preferable lamp, etc. First, I may say that I do not think it is necessary to my argument; nor is the argument specially pertinent to meet a question of that kind nor do I feel called upon to answer such a question. I am free to say, however, that Mr. Edison's platinum lamps have not attained a large commercial use. They were quickly followed, by Mr. Edison and by others, by better lamps. Nobody questions but that carbon is a better material than platinum. Mr. Edison found it out; others found it out; it was known beforehand. There was a difficulty in manipulating carbon so as to get a sufficiently high resistance. That was where a wide field was opened for all inventors; and when a man found out how to do that, how to take carbon and bring it into filamentary form, and have it stand—when this man found out one method, and that man found out another method, and a third man found out another method, then the lamps were made that were better than platinum, and these lamps are what are in use to-day. I see my brother Lowrie smiling. He thinks that that statement is a recognition of the value of this carbon lamp which is the subject of this suit. I think not. Our theory in regard to that is that that was worth no more, nor as much as the platinum lamp. If other inventions had not been made, that lamp would never have been heard of. There was no better than Mr. Edison's earlier platinum lamp. That earlier platinum lamp was a practical lamp, and we have the authority of the Edison company's own witness, Dr. Chandler, of this city, for the statement that if no better lamp had been invented, those platinum lamps would have been practical, commercial structures, provided only you could have had Mr. Edison's later investigations, the feeder and main distribution system, to use in connection with them. When the feeder and main system was invented the platinum lamp was not used in connection with it, because better lamps had been devised. Mr. Edison had devised better lamps—not this thing, not this tar-putty spiral—he had gone beyond that; he had got up something that was useful. Other men had got a carbon lamp that was useful, and Mr. Edison had got up a bamboo lamp (paper was the first lamp put on the market). He patented a bamboo lamp because it had a filament of bamboo carbon. There was an advance which he deemed patentable, and which the Patent Office deemed patentable.

What I am contending for this moment is that this great principle which these gentlemen would credit to Mr. Edison, of the relation between high resistance of the burner and small cross section on the one hand, and the amount of copper required to carry the current from the dynamo to the lamp, is not and cannot be a part of the patent in suit.

There was a French patent to Khnotinsky granted in 1875, and an American patent granted to Woodward in 1876, which are referred to by the witness, but the two patents are not in evidence. I forget why they did not find a place in the record. I think it was by oversight, as at the last moment we found in relation to some other matters. But those two patents are of value here simply because at that early date they show an arrangement of incandescent lamps in multiple arc. You will remember that King does not speak about lamps in multiple arc; nor does Robertson speak about lamps in multiple arc; but in 1875, in the first patent to Khotinsky, the arrangement of incandescent lamps in multiple arc is shown in two or three of the drawings, and is described, and also in the Woodward American patent of 1876 a carbon lamp is described, and the arrangement of that lamp in multiple arc is set forth.

I come now to consider the Lane-Fox patents. Reference was made to those by Dr. Dyer in his opening; and while I have made some quotations from these patents on page 32 and following of my brief, I will not trouble the court to read those at length. But you will certainly find there revealed as fully as in Mr. Edison's French patent the principle of the relation existing between the high resistance of the burner of an incandescent lamp and the amount of copper required on the conductors between the dynamo and the lamp when it is proposed to arrange the lamps in multiple arc. In one of the Lane Fox patents; he speaks also, in order to obtain this high resistance, of curling a strip of wire in the form of a spiral, and he says that the length and thickness of the spiral will depend upon the intensity required and the electromotive force required available; and then he proposes to introduce that spiral into a globe and to seal the leading-in wires, and make the whole vessel airtight. Afterward the air is to be removed as completely as possible, and the top sealed up, some gas being previously admitted if desired, as before described. He does not insist upon having an absolute vacuum there, but speaks of introducing some gas for a certain purpose and under certain conditions, just as we shall find in one of Mr. Edison's patents, taken out in the year 1883, that he says it is desirable not to have too high a vacuum, and that it is better after having taken out the air with the oxygen that it contains to let in an inert gas.

In another of Lane-Fox's patents he proposes to make his burner out of "two highly refractory materials, one of which is a conducting material such, for example, as plumbago, and the other a non-conducting or bad-conducting material, such, for example, as magnesia, zirconia, lime, steatite or earthy matter."

He says: "I mix or compound these materials in such proportions as to make the whole give a specific resistance in accordance with the electromotive force employed for producing the light."

In other words, he wants there to get very high specific resistance. He uses carbon, but instead of relying upon the porosity of the carbon alone, he proposes to incorporate with it some highly resisting substance, so as thereby to increase the resistance of the wire or burner. He uses the carbon as the conductor for the current. He adds to the natural resistance of the carbon by incorporating with it a certain proportion of a substance which is more highly resistant than carbon itself. And in the same patent he speaks of using 140 volts of electromotive force, and says that the "luminous bridge" should have a resistance of about 300 ohms. He concludes this specification by this statement:

"The parts before described are hermetically inclosed within a globe or other form of glass, or other suitable material, through one portion of which the conducting wires are hermetically carried. From this globe all trace of oxygen, carbonic acid gas, water, or any gas or vapor capable of attacking or affecting the material of the luminous bridge when at a high temperature must be removed."

There are certain British patents to which I made a very brief reference on page 36 of my brief, being patents of Scott, Pulvermacher, and Van Choate, all of earlier date than Mr. Edison's. The principal value of these patents is that they show methods of shaping the carbonizable material before the carbonization, and the resultant products being employed for electric lighting purposes, either as pencils for arc lighting or as burners for incandescent lighting. I think that Scott and Pulvermacher make no mention of using these carbons produced by shaping before carbonization for incandescent work, but Van Choate is very distinct in relation to that.

The utility of carbon as the proper material for the burners of incandescent lamps had become well known. King points out in explicit language the great advantage of carbon.

Again, the utility of a high vacuum to protect the carbon burner from destruction was well known. King had it and Roberts had it. King proposed to use the highest attainable vacuum at that day, the Torricellian vacuum. Roberts talked of making the vacuum as perfect as possible, and said that there would be no combustion if the vacuum was perfect. In that connection it would be pertinent to quote a single paragraph from the statement made by his Honor, Judge Bradley, in the McKeesport suit, which was found on page 388 of vol. I:

"Long prior to 1878 it was a well-known fact in science and the arts that the transmission of the electric current through a pencil of charcoal interposed in a metallic circuit would produce intense light; and that when this charcoal was guarded from contact with oxygen in a vacuum or otherwise it would not be consumed. This is fully verified not only in scientific writings, but by the statements found in several of the patents referred to."

Another thing which certainly had become one of the postulates of the art was the desirability of making a receiver or globe entirely of glass, as a means of preserving a high vacuum within a vessel into which the electric current is to be passed.

Another thing was fully established by the patents to which we have referred, the use of fine wires of platinum as the material for leading wires, where the electric current is to be carried through the walls of a glass globe into a vacuum.

Another thing was the arrangement of incandescent lamps in multiple arc, in order to secure a wide distribution of light from a single source of electrical supply.

Also the necessity of giving the burner a high total resistance, in order to secure wide distribution in multiple arc, and as a means of diminishing the size of the distributing wires by which the current is conveyed from the source of electrical energy.

Also the idea of making the burner of an incandescent lamp of small cross section. I have but recently gone over those English patents, and have shown you the making of electric light carbons, which consisted in reducing them to shape before carbonization; therefore, in that there was nothing new, and no discovery made by Mr. Edison.

The manufacture of electric light carbons by carbonizing a mixture of lamp-black and tar or equivalents also was old. We find that in the Gauduin process, the Carre process, in the Pulvermacher patent, and others.

With that view of the prior state of the art and summary of the things we deem to be old, and of the things for which we find an answer to the claim of novelty, let us proceed to discuss a few of the points brought forward by Prof. Barker, professor of physics in the University of Pennsylvania, and which he has carefully formulated as being the elements of importance in the invention disclosed in this patent. If you will turn to page 65 of vol. I. you will find that Prof. Barker credits Edison with "having made a new departure in the art." The context will show that he means by that a new departure by reason of the invention covered by this patent—the new departure consisting in four features, which he enumerates as features of importance.

He says:

"The new departure in the art thus described embodies several features of importance:

"(1) The carbon burner has a small cross section and presents a small radiating surface even when giving considerable length.

"(2) The filamentary carbon burner is made of a peculiar kind of carbon, *i. e.*, one produced by the carbonization of a material, the volatile portions of which pass off during the carbonization, leaving a porous carbon residue of high resistance."

That is what we understand to be a purely structural carbon; and we think that at the time when Dr. Barker formulated this analysis of the Edison invention he was not aware of the fact that the defendant's carbon was a treated carbon, and that its resistance was reduced from 50 to 90 per cent. after carbonization by the treatment to which it was subjected by the carbon that was brought in and deposited all through the porous structure. That came out afterwards.

"(3) The filamentary burner is made by first reducing the material to the size required, or selecting a material already in the proper form, and then carbonizing it.

"(4) An exhausted and sealed glass bulb is employed to contain the burner, which bulb, as we afterward see, is made of an entire piece of glass closed at all points by the fusion of the glass, and capable of maintaining a vacuum, as distinguished from the separable lamp chambers with cemented joints before employed."

I do not know that I ought to consume much of the time of the court in dealing with the first one of these propositions which Dr. Barker has put forward, embodying what he regards as the first of the four specified features of importance in Mr. Edison's great invention. That assumption on the part of Dr. Barker has been taken up and dealt with elaborately by defendant's witnesses. We say that there was no invention in giving the carbon burner a small cross section or making it of a small radiating surface combined with considerable length—stated by Prof. Barker to be the first of the essential features of the "new departure in the art" with which he credits Mr. Edison.

Prof. Cross says on this point:

"The value of this principle in the construction of an incandescent lamp is evidently entirely independent of the material of the burner. This principle has been recognized and employed with platinum wires ever since the fact was first known that platinum could be heated to incandescence by electricity."

He says that the principle is recognized in the case of incandescent lamps, in the platinum lamp of King, in the Edison United States patent platinum lamp, and in the British patent of Lane-Fox. Then he adds:

"So far as the mere use of this principle in a lamp with carbon as the material of this burner from being a new departure, that in my opinion would not involve the slightest trace of invention. But the application of the principle in question to incandescent lamps with carbon burners was by no means new with Mr. Edison. The carbon lamps of King, Roberts and Lane-Fox, as set forth in their patents already referred to in my previous answers, possess carbon filaments whose cross section is small, and the desirability of this construction is insisted upon in these patents."

In that connection I would like also to call attention to the testimony of Mr. Shallenberger, vol. III., page 1,389, question 32. This has to do simply, as your Honor remembers, with the question of proportioning the old burner so as to have a small cross section, which will give a high total resistance. This witness is a graduate of the United States Naval Academy, and a gentleman competent by education and experience to answer the question which is put to him:

Q. If, in the year 1878, lamps like the Bernstein lamp—Let me explain. The Bernstein lamp is a low-resistance lamp, in this sense, that while it has a carbon burner the carbon burner is of large cross section, so that the total resistance is low—so low that the lamp is not capable of use in multiple arc. It is used only in series; and the Edison company make lamps under this patent, I believe, which are capable of use only in series because the total resistance is so low. The Thomson-Houston company make lamps which are known as series lamps, having a low total resistance. It is with reference to those lamps that this question is addressed to Mr. Shallenberger.

Q. If, in the year 1879, lamps like the Bernstein lamp or any of the Edison municipal lamps had been shown and explained to a person familiar with the laws of electricity and such person had been requested to construct or direct the construction of other lamps of the same general character, but which should be adapted for use in multiple arc, the candle power of the lamp remaining unchanged, would such person have known the nature of the changes in the size and proportions of the carbon that would be necessary to effect the desired results.

A. Long prior to this date the laws governing the distribution of electrical energy in circuits were well understood, and I see no reason to doubt that any one familiar

with these laws would have easily arrived at the conclusion that a carbon conductor of low resistance was unsuited to extended distribution in multiple arc; and since the fact was well known that any two conductors of the same specific resistance were of relative total resistances directly proportional to their lengths and inversely as the cross sections, it seems evident to me that the line of modification required would have been indicated at once by a knowledge of this principle. And here comes the more important part of his answer. I was myself at this time familiar with calculations relating to distribution of currents, both in multiple arc and series circuits. As a student of engineering at the United States Naval Academy, I was frequently required to solve problems of this exact nature for the purpose of determining the proper proportions for torpedo fuses and their leading wires and the battery pressure required for their proper operation. These problems included arrangements in multiple arc and in series, and general investigation of the proper relation of resistances in the devices to be operated, the leading wires and the batteries or dynamos. I was familiar at this time with the fact that where it was desired to obtain a heating effect from the current, as in the case of a torpedo fuse, that it was necessary to have the combined resistance of all the fuses in circuit high enough to be suited to the resistance of the leading wires. I was also familiar with the fact that if a number of conductors to be heated were to be arranged in multiple arc, the combined resistance would be much lower by so joining them, unless at the same time the resistance of each of the conductors so joined together was made great proportionately to the number connected together.

In other words, in the examination of the problems that were presented to him at the Naval Academy he had come to know that if you take fuses of a certain resistance and arrange them in multiple arc and put a given current through, you would not get those fuses high enough to explode the mine. You had under that arrangement of the fuses to increase their total resistance, the resistance of each one of the fuses, and in that way you could concentrate more of the effective electrical energy at that point, and so get the requisite heat to ignite the powder or other explosive. It was a question of adjusting the resistance according to the system of distribution that it was proposed to employ. The law in that regard is no different as applied to the resistance interposed in an electric circuit for the purpose of getting heat from which light will emanate from what it is when applied to resistance interposed in an electric circuit for the purpose of getting heat with which to ignite an explosive.

There were a great many interesting questions put to Mr. Edison upon this subject, and I do not think that they were frankly and ingenuously met. I will not say that they were dishonestly evaded, but they were not met in a frank and manly manner. The object of the question was to search the conscience of this inventor, and to know whether he really believed that he had made a great invention or discovery when he announced to the world this relation existing between high resistance and small radiating surface on the one hand and the amount of copper in the circuit in the other. The question to which I now specially refer constituted a part of his deposition found in vol. IV., at page 2,568. While I know full well that in the case of a voluminous record like this it is not expected of the judge to examine every page and read every word—for that would be a physical impossibility—and the attention of the court will naturally be attracted to those things that are specially emphasized in the briefs submitted, yet I cannot resist the suggestion that the defendant would hope that the court might find time to read every word of this not extended deposition of Mr. Edison. This is the deposition that was taken under an order issued by your Honor, where you imposed upon the defendant the burden of calling Mr. Edison, not, as I understand it, with a view to making that man the witness of the defendant, but, under the peculiar circumstances of the case, for the purpose of putting upon the defendant, in the first instance, at any rate, the expense connected with that transaction. Therefore the deposition is really in the nature of a cross-examination of the witness:

Q. You recognize the fact, do you not, that in this art of incandescent lighting there is a certain practical relation existing between the size and proportions of the incandescent burner and the character of the conductors employed to carry the current to the lamp?

A. That depends upon what system you use.

Q. I assume, and ought to have said in my question, that the lamps are to be arranged in multiple arc.

A. There is no such relation.

Q. Do you consider yourself the discoverer of that relation?

A. I do not consider myself the discoverer of Ohm's law, and Ohm's law will explain all things that have been done, and it will probably explain everything that will be done in the next thousand years in electricity.

Q. Is that the best answer that you can make to the question?

A. I don't like to be drawn in as an expert; I am not an expert on the question of words. I will answer questions of facts but I do not like to expert.

Q. It does not occur to me that I am examining you as an expert on this matter; I simply ask you whether you consider that you are the person who discovered the relation that exists between the size and proportions of the burner of an incandescent lamp and the character of the conductors employed to convey the current to such lamp when the lamp is being used in multiple arc?

A. I do not know whether I am or not in relation to an incandescent lamp. Ohm's law did not mention incandescent lamps. It is a broad general law. I think I have already stated a sufficient answer.

So he goes on; and pretty soon he begins to quarrel again with Ohm's law.

Q. I will put this question, then: Didn't you know, as a matter of inference from Ohm's law, at the time when you began your experimentation with incandescent lamps, that with a given size of conductor it would be necessary to give the individual lamps a higher resistance if they were to be used in multiple arc than would be necessary if they were to be used in series?

A. It is not necessary in applying Ohm's law at all, but when you bring in the commercial element in connection with that law, then it is; the fact of the matter is that at the time I experimented on the incandescent lamp I did not understand Ohm's law.

Q. Do you mean that you did not know the formula of Ohm's law at that time?

A. No, sir; I did not know it.

Q. When did you first get knowledge of Ohm's law?

A. It may seem strange for me to state that I do not really understand Ohm's law to-day.

Q. I do not ask you whether you understand Ohm's law, but when did you first know of this law?

A. I have heard of Ohm's law for the last 20 years.

Q. What do you mean by saying that you did not know Ohm's law at the time you began experimenting with incandescent lamps?

A. I mean to say that I did not understand Ohm's law. I do not understand Ohm's law now, and, moreover, I do not want to understand Ohm's law. It would prevent me from experimenting.

You see that we did not get an answer to our question. We put to him a fair and honest question, intended to search his conscience as to whether he believed that he was the man who discovered this wonderful relation between the size and proportions of the burner and the character of the circuit for the current from the dynamo to the lamp. The thing which formed the burden substantially of the opening argument, the thing in which this great merit consists, as our friends would have you believe, is this relation; and I think we are fairly entitled to an answer to the question. But what does Mr. Edison do? He flies into a quarrel with one of the great laws of nature, and says that he does not understand it; that he does not know and does not want to know what it is.

I would also like to call the attention of the court to the testimony of Dr. Chandler, of the Columbia School of Mines, another witness for the Edison company. You will find his testimony at page 5,203 of vol. VII. He was there testifying in relation to the date of another patent, and what he said as to that date he subsequently said would apply to the date of the patent in suit.

Q. Is it your opinion that domestic illumination with lights comparable in illuminating power to ordinary gas jets could have been successfully introduced by means of the system of distribution in suit, with such lamps and other apparatus as were known at the date of the application for the patent?

A. It is.

Those lamps were, according to this patent, and according to the contention of our friend upon the other side, lamps of low total resistance, four ohms and under.

Q. Is it your opinion that mere engineering or mechanical skill would have been sufficient for adapting forms of lamps, dynamos and other necessary appliances known at the date of the application for the patent in suit, for producing the result stated in the preceding question in connection with the system of distribution described in the patent in suit?

A. It is.

In other words, according to the opinion of Dr. Chandler, some ingenuity and mechanical skill were sufficient to change the proportions of the old lamps, antedating Mr. Edison, into such proportions as would make them available for use in large numbers in multiple arc work.

Now, was there invention on October 21, 1879, in putting a piece of carbon, I don't care what its shape may have been, into a highly exhausted globe, when that globe was made out of one piece of glass, as distinguished from two pieces of glass that were held together by some mechanical joint?

Mr. Cross says that there would have been no invention in June, 1879, in putting in carbon wire, if you had had a carbon wire in place of the platinum wire of the Edison platinum lamp. His argument is a very simple one. Among other things he says that he can see no more invention in putting a piece of carbon, if you had it to put in, in the place of platinum, than there would have been in putting an improved kind of platinum in place of the first and inferior platinum that Edison may have used.

And your Honor will recall perhaps that in one of the Edison patents relating to his platinum lamp he discourses at length upon a special mode which he has invented of preparing platinum to be used for that purpose. Instead of taking the ordinary platinum wire of commerce, he proposed to take that wire and treat it electrically in a vacuum, so as to consolidate it, and thus he says he can from the same piece of platinum that previously, before the treatment, would give but three candles of light, secure twenty-five.

Now, if in his first platinum lamp he had used, as doubtless he did, the ordinary platinum wire of commerce and found that it was not sufficiently durable, and then had made this improved platinum wire for the older and inferior platinum wire, the invention would have been in the process of treating the platinum wire, whereby it was made superior to the old article.

So to-day we have these lamps with a carbon of a certain quality, not perfect carbon, not the ideal carbon—it has its imperfections. If to-day I devise some method of making a carbon that is largely superior to anything that Mr. Edison, or Mr. Maxim, or Prof. Farmer, or any of the other inventors have made, is their invention involved in substituting the superior carbon for the older and inferior carbons? I apprehend not.

There is another very interesting patent of Mr. Edison's to which I will ask your Honor's special attention. It is found in vol. VI., at page 4,660. It is strikingly like the old King lamp of 1845. The lower part of the glass receiver, instead of being closed by a fusion of the glass upon the leading-in wires, is extended down into two long barometric tubes, and the leading wires run down into the mercury in those tubes. That is the seal which, in the year 1880, June 30—for that was the date of application—Mr. Edison said would be an excellent thing for lamps having a large radiating surface. He says with reference to this kind of seal:

"For high candle power incandescent lamps this arrangement makes a very reliable and durable seal, obviating any danger there may be of seal breakage arising from difference of expansion coefficient likely to exist where a large metallic conductor is sealed directly to or in glass. For such reason, in large lamps, this method may prove preferable to that of sealing direct, as shown in some of my prior applications."

In view of that patent we trust our friends upon the other side will not say that the King lamp is to be thrown out of consideration by the court because, forsooth, you couldn't maintain a vacuum in it.

Then we have in evidence, your Honor, some exhibits illustrative of the Sawyer and Man methods of sealing or closing up their receivers. They show in their earlier patents of 1878 a closed chamber which had a metallic base. One patent also showed a glass plug entering the throat of the glass case. We have had lamps made, they were used in the McKeesport suit, showing that same method of constructing the globe. They were exhausted to a very high degree of tenuity; they were put on a test and run some of them for 200 hours, without any impairment of the vacuum; and they were then introduced into this case, being subjected to a later test, after lying idle for a year or so, to see whether the vacuum was still maintained intact. It was found that it was, and Mr. Shallenberger, who carried on those experiments, the gentleman to whom I refer, who is a graduate of the Naval Academy at Annapolis, testifies that those experiments demonstrate beyond any doubt the entire practicability of such a lamp structure.

We now take this position, that the lamp of the patent in suit was a most inferior structure, and, in fact, made no more impression upon the art than did the inferior platinum lamp which Mr Edison made in the year 1878; not the one covered by the French patent, not the one covered by the American patent, to which attention has been called, but before that, in the year 1878, he developed a platinum lamp and set the world on fire with it It was that worthless platinum lamp of Mr. Edison's which he exhibited at Menlo Park some time in November or December of 1878 that caused the great panic in gas stocks in London. It set the Bourse in Paris in commotion, and the stocks on those great exchanges went down seven and eight and fifteen per cent. in consequence of that announcement.

The lamp was of no value. It produced a profound impression in the world, but was never heard of after a few days' time. It gave great éclat and notoriety to Mr. Edison. But this lamp was as worthless, according to our conception of the thing, as was the earlier platinum one.

It was only when improvements have been made, only when the art has progressed beyond these two worthless things of that original open platinum lamp and this coil of tar putty, spiral carbon lamp, that the world began to appreciate that there was some economical and practical value in an incandescent lamp.

And, even so, the development of the art was excessively slow. Down to the year 1882 the Edison company, with their enormous capital, had only put upon the market 34,000. Nearly two years after, the date of the issue of this patent, they, with all the accumulated inventions that had come into the art, and which were placed at their disposition, had only succeeded in selling 34,000.

But in this connection we have that most interesting testimony of Prof. Chandler, who says that before the date of this invention there were good practical commercial lamps in existence. They couldn't be used because there was not known to the world at that time a feasible system of distribution. If only that had been known, the other lamps would have come in and played an important part, and among them he names with emphasis Mr. Edison's earlier platinum lamp, having all glass highly exhausted globe. Accordingly, I deem this point of so much value that I shall make no apology for reading some extracts from Prof. Chandler's testimony.

Your Honor has heard about the witnesses who were called before the Parlimentary committee in England, in 1879. Dr. Chandler had a question addressed to him of this character:

Q. Assuming the state of the art existing in 1879, at the time when the various witnesses whose testimony you have quoted were examined before the Parliamentary committee, would the invention described and claimed in the patent in suit, without any further invention by Mr. Edison or any one else, have constituted, in your opinion, a practical solution of the problem of the subdivision of the electric light, which you have said was regarded as very difficult, if not impossible of solution, by those witnesses?

That is the "feeder and main" patent, your Honor.

A. It would; for the reason that the three elements necessary would have been available: Incandescent lamps, the source of electricity, that is, dynamos, and the Edison system of distrioution, by which the current could be supplied to the lamp under suitable conditions.

Q. What incandescent lamps were available at that time which in your opinion would have been suitable for the purpose and capable of commercial use? A. There was the platinum lamp, of which several forms have been invented, for instance——

And he refers to the King lamp and the Sawyer and Man, and, about the date of this report, though the patents were issued a little later, the Edison lamps, the Swan lamps, the Lane-Fox lamps.

Q. Is it not a fact that the literature of the subject shows that the general conception of the nature of the problem of the subdivision of the electric light, as it was understood prior to 1880, was that it related to the production of any kind of electric lamps having illuminating power equal to a common gas jet and adapted to like purposes, which should possess such characteristics as would make it practicable for one generator to operate a considerable number of them located at reasonable distances from it, and which at the same time should be economical, durable and cheap enough to make them commercially useful, and so simple and reliable that they could be placed in the hands of the public to manipulate?

A. The lamp described in the question was undoubtedly recognized at that date as one of the necessary elements of the problem of the subdivision of the electric light; but at the same time it was recognized that the problem included as an equally essential part of the problem a system of distribution so arranged that no more current would be called for than was necessary to actuate the lamps in actual use at any given time, and to supply a suitable current with such economy in the cost of conductors as would make the system practicable, and it is hardly necessary to say that every electrician realized the fact that the current sent out must be of such a character as to tension and uniformity as to properly actuate the lamps.

Q. Would such lamps as the Edison platinum lamp and the Lane-Fox lamp referred to, be, in your opinion, such lamps as could have been successfully used for the practical introduction, commercially, of domestic illumination with lights comparable in illuminating power to ordinary gas jets by means of the system of distribution described in the patent in suit, if no better lamps had been produced?

A. I think they would.

The COURT: This was his testimony of the "feeder and main" suit.

Mr. DUNCAN: In the "feeder and main" suit, another suit pending in the District of New Jersey against Westinghouse, Kerr & Co.

The COURT: In which he was a witness?

Mr. DUNCAN: In which he was called as a witness for the Edison company, the complainant here. While the defendants are nominally different yet it is conceded by stipulation that the defense is being conducted in both cases by the Westinghouse Electric & Manufacturing Company.

I have only this further comment to make, then, that this piece of testimony of Prof. Chandler shows the wonderful adaptability of the Edison company. Like the chameleon they change color with their environment. If you put them on the tree of the feeder and main patent everything takes on a brilliant rainbow hue, and they find that that is the tree whose roots strike down to the centre of the earth and whose branches spread over the whole earth. If you put them into the carbon filament tree everything takes on a golden hue there, and I suppose their witnesses, then, reasoning from the standpoint of that position and the necessities of that case, find that everything is turning to gold for that reason. They don't seem to have the proper perspective. When they get into the presence of one case that fills the whole vision, and they go into the presence of the other case and that takes up the whole vision. They take a little dime and hold it too near the eye, and it becomes a cartwheel that excludes even the sun from the heaven.

This whole subject of the development of a new art, the creation of an art by Edison, was fully discussed by Morton and Cross and others, and they gave their reasons in full in support of the general proposition that this lamp played a most insignificant part, if any part at all, in the development of the art. In fact, the art was developed—not created at that time, but developed—from its earlier state by the labors of many men and by many inventions made by each one of the noted inventors who were working in this field of industry. One of the bulletins that were issued by the Edison company in 1883 contains this statement which was of importance in this connection:

"Mr. Edison holds 83 other patents"—three had been specially named—"already granted in this country on the lamp alone, and has applications for 75 more patents on the lamp alone now awaiting decision. . . . These patents allowed to Mr. Edison on his lamp are only a small portion of the patents allowed to him in connection with the use of the lamp up to the present time.

"No less than 227 patents have been allowed to Mr. Edison in the United States alone on his lamp and on the details connected with its manufacture and use. And he also has 175 additional applications for patents on the same subject now awaiting examination at the Patent Office."

And one of the patents which had been granted to him was that patent with its broad fundamental claim, where he shows the platinum lamp and makes a claim which is broad enough to cover every incandescent lamp that is now in commercial use, whether platinum be employed or carbon or anything else, and in that patent, which covers an invention made by him before the date of the invention of the patent in suit, he had pointed out, had elaborated most fully this great fundamental principle of high resistance and small radiating surface, and the relation of those two things to the character of the circuit wires.

If there is anything fundamental it must be in that earlier invention of Mr. Edison. That patent is not here involved. That patent probably will never appear in the courts again, because, in view of the radiometer of Mr. Crookes, it seems impossible that the claim that was allowed to Edison there can ever be maintained.

I don't suppose that your Honor will for a moment apprehend that the Edison company regard the commercial lamp of the present day, as made by them, to be under this patent alone.

An interesting piece of testimony bearing upon this subject is found in Mr. Upton's testimony. He was asked this question:

Q. Have the Edison incandescent electric lamps, manufactured by the Edison Lamp Company, been provided with any marks or labels showing the fact that they were patented, and if so, what has been the character of such marks or labels, and how long have they been used?

He then goes on to show that in the year 1882 they put onto their lamp a little label, pasted it onto the globe, and that recited five patents; that then they took that off and simply put on a smaller label showing "Edison's patents," and put a big label onto the barrel heads in which the lamps were packed. There is the label (showing label to court). It contains a list of 121 patents, and the very first patent on the list is a patent granted to Woodward in the year 1876.

Now that the court may not misunderstand my position in relation to this, let me explain. This label reads: "Edison Lamp Company, sole licensee for the manufacture of Edison lamps under the following United States patents." It does not in terms say that all those inventions are embodied in each one of the lamps, but the question put to the witness was, "Have the lamps been provided with any marks or labels showing the fact that they were patented?" A fair inference to draw from that is that those lamps embodied 121 different inventions. I don't know that the witness intended that inference to be drawn. Whether he did or not, it won't be disputed that each one of the Edison lamps to-day embodied in its construction many of the patented inventions of Mr. Edison.

As to the views of scientific men prior to the year 1879, in regard to the difficulty of solving this problem of the subdivision of the electric light, the plaintiff has groped around in the literature of the past, and has got together from one source and another a good many utterances going to show that the problem was regarded as a very difficult one, and some men said they doubted if it could be solved. The problem was a very difficult one, and the history of the slow development of the art, even after the attention of the world was turned in this direction by the cheapness with which the current could be developed, shows that it was necessarily a difficult one. The hundreds and thousands of inventions that have been made in order to develop this art are a complete demonstration of the opinion of those men.

I do not find, however, that it is fair inference from the opinions of those men put in evidence that they regarded it as impossible or an extremely difficult thing to make a lamp that could be used for the purpose of incandescent lighting.

Judge Bradley, at that passage in his opinion where he is referring to Patent No. 223,898, does say that, "the principal and great thing described in that patent is the attenuated filament and its inclosure in a perfect vacuum." Those were the words that my friend desired me to read yesterday. He says that, "but for this discovery, electric lighting would never have become a fact. It is undoubtedly the great discovery in the art of practical lighting by electricity." And elsewhere he says that "the great discovery in the art was that of adopting high resistance in the conductor with a small illuminating surface and a corresponding diminution in the strength of the current. This was accomplished by Edison in his filamental thread-like conductors rendered practicable by the perfection of the vacuum in the globe of the lamp."

Now that does not make for this present patent at all; not even according to Judge Bradley's conception of the matter. In the first place, your Honor will note in all that Judge Bradley does not use the word "carbon." He does not say that it was the putting of a piece of carbon of high resistance and small illuminating surface into this vacuum that laid the foundation of this problem, or which was the solution of the problem.

He adds also these words, and it is a complete answer, it seems to me, to the argument that our friends on the other side would draw from these general forms of statement made by his Honor in the McKeesport suit. He says:

"This great discovery . . . is well indicated and shown in Edison's patent applied for in April, 1879, and issued May 4, 1880, No. 227,229."

That is the patent covering the platinum lamp; and it is the same great discovery that was shown in the French patent that was issued in June, 1879, and the Italian patent of that date, and through that medium had become spread all over the world.

The discovery was not new with Mr. Edison; but conceding for the moment that it was, it was not revealed to the world by Mr. Edison in the patent now before this court.

The only real question, then, for consideration in this case should be whether there was patentable novelty in Mr. Edison's special mode of making his burner and in his mode of fixing it in position. If the patent be restricted, as the defendant insists it must be, to the making of the burner by the process of carbonization pure and simple, unaffected by a subsequent treatment, that would reduce its resistance; nor if it being restricted to the curling of the burner into a close spiral so as to mass a part of its surface, in order to get a high resistance without changing the radiating surface, or if it be limited to the securing of that burner to the leading-in wires by the use of an elastic carbonizable cement, then the defendants do not seriously contest. They have no interest then in contesting the patentability of the invention, as disclosed in the patent. But if the claim made by the plaintiff is that this patent covers broadly the combination of a carbon burner, even when restricted to the form of an attenuated filament with a highly exhausted, hermetically sealed glass globe, then we say the whole logic of Judge Bradley's decision is against them. There is another point which has been very much dwelt upon in the opening argument for the complainant in the brief submitted, in the testimony of the expert, as going to prove great merit in Mr. Edison's work, as revealed in this patent. It is the proposition that Mr. Edison discovered a new property of carbon.

The claim started in this way: Prof. Cross, your Honor will remember, testified that in April, 1879, it would not have required invention in his judgment to have substituted a carbon wire for a platinum wire in Edison's platinum lamp, provided—he was guarded in that—provided you had a carbon wire that could be put in there.

Well, Mr. Clarke takes up the cudgels and says that proviso takes away all the force from the testimony. Prof. Cross would not have known in the first place the size and proportion of the burner because he would not have known the specific resistance of carbon, consequently he would not have known that a carbon wire or filament if put in a highly exhausted globe would have been endurable; he would not have known but what it would have suffered disintegration; and when Mr. Edison tried the experiment and found that it would not disintegrate he discovered a fact not known to the world, and he discovered a new property of carbon—that is the form in which they have stated it—and the changes have been rung upon that, and will be rung upon it still more by the complainant.

Everybody knew what the specific resistance of carbon was, just as they knew what the specific resistance of platinum was. It was simply a question of the relative conductivity of those several materials as compared with the standard mercury, and it is all written in the books, and we have here a record produced by Dr. Morton showing what the specific resistances were taken from publications in the year 1858.

But another piece of testimony of Mr. Edison's is found.

Q. Is it not the fact, Mr. Edison, that as soon as you had made a highly exhausted all-glass platinum burner lamp, and found that it would maintain its vacuum, you were confident that a carbon filament would remain stable in that same vessel and vacuum, provided you could make the filament homogeneous?

A. I believed that by substituting a filament of carbon for that platinum, it would be stable. I did not have any doubt but what I could make a filament of carbon sufficiently homogeneous for the purpose; the platinum lamps which I used, however, did disintegrate to the extent of tinting the globe with a vapor of platinum, and I supposed that this effect would take place even when I used a filament of carbon under the conditions, but I hoped it would not be to such an extent as to render it uncommercial, and I was surprised to find that it did not blacken at all, and that is the discovery that I set forth in the patent, and I have emphasized the word "stable" and used instead the words "absolutely stable."

Now Mr. Edison knew by a prior reasoning, as I interpret those words, that when he had got a permanent vacuum, he could put carbon in there where platinum had been before, that he could put in a fine piece of carbon where there had been a fine wire platinum. He did not think that there would be some blackening. He did not think it would not blacken at all.

Now our friend Mr. Clarke has seized upon that statement, that it did not blacken at all, and the statement is made a great deal more positive by Mr. Edison in other parts of his testimony, where he says, "I supposed it would disintegrate somewhat; but I did not suppose that it would not disintegrate at all."

That was the great discovery that he made, according to his version of the matter, and if he had made such a discovery as that, it would have been a wonderful discovery indeed. He never made it, your Honor, for no such fact exists in nature; and I shall invite your attention to two or three parts of the testimony here for the purpose of clinching now that error as I understand it, in regard to this hypothesis that Mr. Edison discovered a new physical property of carbon, and therefore is entitled to special consideration in interpreting this patent. Mr. Edison tried an experiment; he tried to see how small a piece of carbon could be used in a lamp. He was surprised to find that the very thin piece with which he made the experiment endured as long as it did; but it was a short time. He did not observe during that brief experiment that there was any actual blackening of the globe. He jumped to the conclusion, therefore, he tells us, that there was absolutely no disintegration. He believed that the carbon would stand, he hoped it would endure long enough so that it would be a commercial lamp, and that was a very natural conclusion for him to come to, for anybody to come to, that the better you make the vacuum the better the carbon will stand. He had had experience by putting thick, heavy carbons under bell glasses on his air pump and exhausting the air, and he found that the carbons would disintegrate. As you improve your vacuum, you take away the consuming gas, and naturally the slight residuum left will produce less and less and less disintegrating effect upon the carbon. If you could take it all away, wouldn't you expect the carbon to be absolutely permanent? Now, Mr. Edison was reasoning that way, and he tried this experiment to see how small a carbon he could put in there and have it stable. But the fact is, your Honor, that it is a matter of degree only; for in all the lamps that have been made from that date down to the present time, this process of disintegration is going on. Mr. Edison in this patent proposed to go up to one-millionth of an atmosphere, thinking that thereby he would get better results still.

There is one patent of Mr. Edison to which I would like exceedingly to call attention in this connection, found in vol. VI., p. 4,701. This is what is known in common parlance as Edison's low-vacuum lamp patent. He starts out with the significant statement that the very high vacuum that he has been relying upon to preserve his carbon filaments, when sealed up hermetically, was really destructive of the carbons, and he gives as a result of his experience—this patent, your Honor, was applied for in November, 1882—he gives it as a result of his experience that with these very high vacua, "electrical carrying" takes place to such an extent as to impair the value of the lamp. He goes on to tell us what this electrical carrying is, and in substance explains it to be disintegration or tearing apart of the particles of the burner and their conveyance over onto the walls of the globe. I am reading from page 91 of the brief.

As a remedy for this he proposes to make use of a low vacuum, instead of a high vacuum, and he suggests 29 inches of mercury as the best. Now that is a vacuum which would be one-thirtieth of an atmosphere, instead of one-millionth of an atmosphere, as suggested by the patent in suit. He tells us how he proposes to get that very low vacuum. He does not want any oxygen there, therefore he proceeds to exhaust the globe just as highly as possible with the best appliances at hand, and having done that and got all the oxygen removed from the globe, then he lets in an inert gas, and this increases the pressure inside, reduces the vacuum and brings it down to the very low point he names. In other words, by that process he returns to the plan which Sawyer and Man and other men, prior to Mr. Edison's date, had used, and adopts the very method which the patent in suit denounces. As the result of a longer and larger and brighter experience of this man, he comes back and, without saying it in words, he in substance tells us that he was all wrong in his denunciation of those earlier lamps, so far as concerns the use of an inert gas; that the high vacuum which is the subject of the patent in suit, in part, which is lauded at any rate in the patent in suit, is, after all, an imposition on the public, and that the low vacuum is the best thing for the life of the lamp, for economy in operation, and that the best way of getting a low vacuum is to do the very thing that Sawyer and Man and others, before the date of the patent in suit, had been doing.

As the result, your Honor, of this consideration of the prior state of the art, I think that we may fairly conclude that Mr. Edison did not invent as the burner of an incandescent lamp a thing having small cross section combined with small radiating surface, nor a thing having a high resistance combined with small radiating surface. He was not the man who originated the conception of high total resistance of the burner of an incandescent lamp which economically affected the question of copper or other conducting material in the mains of the circuit.

We believe that Mr. Edison did not create a new art. We believe that he did not make a discovery of a new physical property in carbon; and if we are right in our contention upon these points we shall argue that the only thing revealed in this patent that was new to Mr. Edison was either his mode of preparing the carbon, substituting the substance of the burner, leaving it in that condition of high porosity that contrasts it with the old carbons and the art, or else it was his mode of shaping that carbon into a spiral form, or else it was his mode of attaching that peculiarly constructed thing to the leading-in wires.

For present purposes I will not linger upon claim 2 of Edison's patent. If we are right in our contention that the element of curling is necessarily present in that claim by reason of the explicit language of the specification upon which that claim is predicated, then that satisfies our purpose, because the burners of the defendant's lamps are not curled or otherwise so as to mass any portion of their radiating surface. At another time we shall consider whether the word "filament" in claim 2 does not necessarily impose limitations that would take the defendant's lamp away from the operation of that claim; but that point I have at present passed, and we come to consider claim 1.

"An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured in metallic wires, as set forth."

That is based upon the statement of invention that

"The invention further consists in the method of manufacturing carbon conductors of high resistance so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading wires and the carbon conductor."

There are three points in that claim that demand special attention: The carbon out of which the filament is to be made is to be carbon of high resistance; then the filament is to be made "as described;" and third, it is to be "secured to metallic wires, as set forth." What is the first condition? That the filament is to be made out of carbon of high resistance. The witnesses seem to be agreed—I think I can safely make that general statement—on both sides that this means high specific resistance.

We now come to consider the second condition in claim 1, namely, that the filament of carbon is to be made as described. As to that we say, in the first place, that it means by the process of carbonization pure and simple, without any supplemental process that will induce a lowering of resistance, and thus give you a carbon other than what was contemplated plainly by the language of the specification. There it may be advisable to recur to the language of Prof. Barker:

"The carbon filaments of the patent in suit are made by a process calculated to give to the carbon as high a

porosity and as low a density as possible consistent with durability."

A little further light should be thrown on this subject, and we derive it from the best source, Mr. Edison's testimony in a Canadian suit, where he was called as a witness, and was duly sworn, his testimony being introduced there in the form of an affidavit. There was a proceeding commenced in the Patent Office in Canada for the purpose of canceling his Canadian patent on the ground that there was a failure to manufacture his invention in the Dominion in conformity with the laws of Canada, and also that there had been importations of the patented article from the United States beyond the line allowed by the statues. Mr. Edison, in order to protect his Canadian patent, gave testimony. He went on to describe what his process of carbonization is and what it always had been from the very beginning; and he distinguishes between his method of carbonization, even for the purpose of producing the burners of incandescent lamps, and the processes practiced by other people for that purpose. He says, quoting from volume 4, page 2,622: "The carbon of the filaments of my lamps is the pure vegetable carbon made by the carbonization of plain bamboo and without the addition by deposit of any mineral carbon.

"My lamp factory in Harrison, N. J., I believe to be the only factory making a carbon of this character, and I consider the success and reputation of my lamp from a commercial point of view to be largely dependent on the fact that I use such a carbon. Other manufacturers of incandescent electric lamps find it necessary to build up their carbons and cure their defects by depositing upon them a layer of mineral carbon obtained by dipping the carbons when in the conditions that they are in when received from the furnace in a hydro-carbon liquid, and then while they are immersed in the hydro-carbon liquid passing an electric current through them, which decomposes the hydro-carbon and deposits a layer of mineral carbon upon the filaments."

There is another condition in claim 1, namely, that the thing named in the claim, the filament, is to be secured to metallic wires, as set forth. What is the significance of that? A natural answer to the question, one which first occurs to the mind, is that found by reference to the language of the specification, column 2, page 1, line 97. After having described the construction of a burner out of tar-putty by mixing the ingredients and rolling them into wire form and curling them into a close spiral—and it is in that connection that the word filament first occurs—the patent says:

"All these forms are fragile and cannot be clamped to the leading wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lampblack and tar material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity of clamps; hence the burner and the leading wires are connected to the carbon ready to be placed in the vacuum bulb.

"When fibrous material is used the plastic lampblack and tar are used to secure it to the platina before carbonizing."

Thus we have the declaration of this patent that this curious thing called a filament—a thing made out of tar-putty rolled out exceedingly fine and then coiled into a spiral—cannot be secured to the leading-in wires by the use of the old clamps that other persons had employed. Previous to this in the specification Mr. Edison has referred to the use of clamps as an objectionable thing. He now says that when he gets this filament he cannot use the clamps with any satisfaction, and he must resort to another method of securing his filament to the leading in wires, and that method is to employ a plastic carbonizable material at the joint and carbonize *in situ*, and if he is using his tar putty filament he carbonizes that union at the same time when he carbonizes the body of the filament. We submit, your Honor, that there is no other plausible explanation of those words occurring in that claim than the one that I have now suggested.

I passed, in considering infringement, a consideration of the significance of the word filament. I only considered the question of infringement of that claim so far as relates to the coiling of the thing called a filament. I now come to consider, though I must do it somewhat hurriedly, whether there is any hidden meaning in the word filament which is of service to the defendant. I say frankly to the court that I do not know to-day what the word filament means. We think, however, that the plaintiff is committed to certain limitations in regard to it. We think that Mr. Edison has so hedged that word around that it cannot mean certain things; and it is upon that ground that we stand when we come here and say that for such and such reasons we have not the thing called a filament; and we say among other things we have not got the filament of the patent because we have not got a burner which has a total resistance when in action of 100 ohms—except in one of our lamps; in the other two we have not—and if that condition of 100 ohms total resistance is imposed upon this burner by the use of the word "filament," then we are for that reason outside of the second claim so far as regards two of our lamps. There are other limitations, as I said, which I think must necessarily attach to the use of the word filament, and which I will consider in due order as time may permit. Before discussing the question whether the term implies 100 ohms resistance hot, permit me to turn aside to consider two suggestions that have come from the counsel for the plaintiff in his opening argument. I understand one argument to be made to the court to this effect: that it is fair to assume that filament in this patent is not limited to 100 ohms resistance hot as a minimum, because that would be inconsistent with the model filed in the Patent Office; that the teaching of that model is that the resistance was not intended to be 100 ohms. Was it? Has anybody measured the resistance of the Patent Office model? No. It is a dummy model, the testimony shows. It has not any carbon in it at all, and never had. It has something coiled up, but it is a piece of uncarbonized thread blackened over; and no attempt naturally was made to measure its resistance; it would have taught nothing. But, says Mr. Howell, "if you will go to work and make a lamp with tar-putty, and make it with my measurement and make it with my composition, I can produce a lamp that will look a good deal like that thing in the Patent Office and that will not have a resistance hot of more than 45 ohms." I don't recollect whether it was 45 or 65 or possibly 40.

I do not think that the next argument presented by Brother Dyer is worthy of more consideration than that. He says, and prays the court almost, not to construe his limitation of 100 ohms into this claim because, forsooth, if you do you cannot prevent the Westinghouse company from going on with some of their low total resistance lamps; you cannot stop them; you cannot kill the industry; you cannot put out your hand and destroy the capital that has been invested here if you put such an interpretation upon this patent. With what grace does an argument like that come from these gentlemen who stood by for five long years with their hands in their pockets looking idly on and seeing this great industry grow to its gigantic proportions; sending out circulars saying, "We own so many patents"—enumerating them one after the other, and warning the world not to infringe any of those patents; not saying, "That patent is infringed by that lamp, and we will hold you to a strict accountability;" offering to-day as an excuse for that delay, what? This: Mr. Eaton, who was president of the Edison company through the years of 1881, 1882, 1883 and 1884, says they knew of the work that was being done by the United States Electric Light Company, but Mr. Edison was too busy in his laboratory to justify their calling him away in order to make him a witness or in order that he might give attention to the litigation. He says that they did not think that the work the United States company was doing had reached sufficient magnitude to justify them in spending any time in litigation, and therefore he thought they had better wait, and the company came to the conclusion that they had better wait until that business should have grown to such proportions that it would be an injury to the Edison Company, and then they would bring a suit under this or some other of their patents; and they waited for five years, and early in that five years the United States company was taking contract after contract away from the Edison company; and in this record there is a protest filed, if I recollect right, over the name of Major Eaton himself as the president of the company, with the Secretary of the Treasury of the United States, urging that no more contracts in the post-offices and custom houses be given to the United States company until another contract, namely, for the post-office in Chicago, should have been given to the Edison company. "Already," says the letter, "you have given a contract in Philadelphia, in the post-office, to the United States company. We have got only one contract, in Boston. We want another, in Chicago. It is true the United States company have underbid us for the Chicago enterprise, but we are willing to come down to their figures and we think we can furnish better lamps. Now it is but equity and justice," the letter goes on to say, "that we should have as many contracts as the United States company." Not doing them any harm? On January 1, 1882, the record shows, the Edison company had sold 34,000 lamps only. March 31, 1882, it appears that the United States company had sold 36,000 lamps. Early in the career of the companies the United States company took the contract away from the Edison company for this building, and took the contracts on these show plants down here on the river, the ferry boats; took from them the contract for lighting the capitol at Albany, and other of the important advertising places in the country; conspicuous contracts were taken away from this company, which all that time never lifted its finger to bring suit against us; but they come in to-day after having waited all those years, and say "Your Honor, don't impose upon this patent the interpretation that the burner is limited to 100 ohms resistance, because if you do, with the methods of distributing currents that are known at the present day, although they were not known then, the Westinghouse company cannot be stopped."

Does "filament" mean a burner whose resistance hot is 100 ohms? That, I agree in the first place, is the lowest resistance spoken of in this patent. Secondly, it is abundantly established by the testimony of Shallenberger, Cross and Thomson that with any method of electrical distribution that was known in the arts at the date of this patent you could not effect practical distribution on the central station plan—that is, large numbers in multiple arc—unless you had a resistance at least as high as 100 ohms hot. Methods have come into vogue since then whereby it can be accomplished, but those methods were not known to the art at that date, and this specification must be interpreted now with reference to the things that were then known. But a better argument than that in favor of this limitation is the language of Mr. Edison himself. We have quoted into our brief from various of his utterances, patents, testimony, etc. I shall not take the time of the court to read them all. In the McKeesport suit Mr. Edison was examined as a witness; or rather, this was in the interference that he had with Sawyer and Man, the testimony being put into the McKeesport record, and being imported into this. Referring to the time of his experiments which led to the invention by him of the paper carbon burner, he says:

"What we desired at that date, and had concluded as the only possible solution of the subdivision of the electric light, was that the lamp must have a high resistance and small radiating surface, so as to be capable of being worked in multiple arc commercially, and our calculations showed us that the lamps must have at least 100 ohms resistance to compete successfully with gas; otherwise, if the lamps were of low resistance, the cost of the main conductors would be so great as to render the system uncommercial."

For that reason we conclude, your Honor, that the term filament was understood by Mr. Edison to mean a thing having a resistance hot of not less than 100 ohms. What else it may have meant is a mystery to us. What his full definition of the word was we do not know; we have not received any lights from the experts for the plaintiff, nor from the brief that has been filed, nor so far from the argument that has been made by plaintiff's counsel. It leaves us in that predicament because the term was new in the art. It never appeared in the art of electric lighting until it was embodied by Mr. Edison in this piece of writing; and under every obligation which the law imposes upon an inventor when he seeks the wide protection that the statute gives him he was bound to define that term with exactness, so that any person undertaking to make the thing which he now for the first time calls filament should know how long to make it, how small to make it, what specific resistance or what total resistance to give it, so that people who did not want to make that thing but something else should know what territory was occupied by another in order that they might keep on the public land. He has not done so. I refer to that now because that is one of the quarrels that we have with this patent. We say that he did not come up to the requirement that the law imposes, and he has given us a document here which is uncertain, vague and indefinite, and we do not know how to act in relation to it. We do not know, when we want to construct a thing, how to go to work except to follow slavishly the indications of the patent and use the tar-putty, coil it and use a certain diameter and a certain length; and if we wanted to depart from that we should not know whether we were getting the thing which Mr. Edison styled a filament or not. Left in that condition of uncertainty we have to do the best that we can to find out whether there are or are not some limitations to be imposed upon it; and we have presented one Another limitation which we say attaches to the language of the patent is that a filament must be a thing so fragile that you cannot use a clamp to confine it to the leading-in wires. Mr. Edison does not employ the term filament in the patent until he comes down to describe his tar-putty construction, and he says these are all so fragile that you cannot clamp them to the leading-in wire, and therefore he resorts to another mode of union. That would seem to be another limitation.

I pass now, your Honor, to consider the bearing upon the interpretation of the patent in the suit of an application that was filed by Mr. Edison in the Patent Office a little later than the issue of the patent. It seems to us that it has a very important relation to the interpretation of this patent. While the application for the patent in suit was pending, namely, on the 11th of December, 1879, Mr. Edison filed in the Patent Office an application, known as the paper-carbon application, in which he described a burner cut out of paper, and he sought to secure a patent on it. He was thrown into interference with Sawyer and Man in relation to that, and a long controversy followed, and Sawyer and Man obtained as the result of that protracted controversy the patent that was put in suit before his Honor Judge Bradley at Pittsburgh in the McKeesport suit. After that interference was declared, some time subsequent to the date of the patent in suit, to wit, on the 15th of December, 1880, Mr. Edison divided off from that paper-carbon application a portion, being that which he said was not involved in the interference with Sawyer and Man, and on that he filed a new application relating back of course to the date of the first application, December 11, 1879. It is to that divisional application which I desire to direct your attention. The application is still pending in the Patent Office, having undergone various modifications. It came to our belief, from various rumors that have been current in relation to it through many years past, that there was matter in that application closely allied to the matter contained in the patent suit; that claims were asserted in that application that were coextensive with the claims of the patent in suit under the interpretation that the plaintiff is undertaking to impose upon that claim. On that condition of things we called upon the plaintiff to furnish us with copies of that application. The matter was taken under advisement, and they courteously but firmly said upon the record, "No." We applied to the court for an order compelling the plaintiff to give us permission to obtain from the Patent Office a certified copy of the application. It seemed to his honor Judge Lacombe that it was an unprecedented step and he declined to grant the order because, among other things, there were other methods by which he thought we might obtain that result if we were entitled to those papers at all. He denied our request without prejudice to our right to renew it. After that we applied to the Commissioner of Patents for a copy of the papers. He said no. We proceeded by an application to the Supreme Court of the District of Columbia for a writ of mandamus to compel the Commissioner of Patents to give us the papers. The court said no. We returned to Judge Lacombe, and Judge Lacombe, on hearing the evidence and hearing protracted argument, said to the plaintiff, "You must produce the retained copies of those papers." The production was then effected in this way. Mr. Dyer, in whose custody they were held, brought them in before the examiner and handed them to the president of the Edison company, and he handed them to Mr. Lowrey, and then they said, "They are produced, but you shall not see them." Then we had a fight as to whether we should see them or not, and we had a protracted argument and submitted briefs, and at last the judge said, "You must show those papers," and they were shown and put in evidence. There was very good reason for withholding the papers. Evidently the plaintiffs did not want us to see them. They, I mean, had a good reason for doing it. They felt that that was a critical point in the case, that it might be the key position, and they fought it for a whole year with all the vigor of the able counsel employed to aid the Edison company. Now when we come to examine the specification that was filed in the Patent Office on that divisional application in December, 1880, we find it setting forth in the first place as the object of the invention the production of a lamp of such a character that "a great number of lamps" may be fed by current "from one source located at what they termed a central station." It sets forth that carbon is universally recognized as the preferable material for an incandescent lamp. It sets forth that prior to Mr. Edison's work it had been customary to treat carbon for such use in order to lessen its resistance, using this expression:

"In fact the practice universally has been to reduce the natural resistance of the carbon, bringing it to a relatively very low point."

Note the language: "To reduce the natural resistance." The patent in suit did not use the word "natural," but said simply "to reduce the resistance"; but here the expression is "to reduce the natural resistance," which means the specific resistance. The patent goes on to describe the great advantage of high vacuum and says you can secure that advantage by the use of a globe made entirely of glass, with the platinum wires sealed into the glass by fusion. It then sets forth the necessity of making the carbon burners of very small cross section, and says that paper is a very desirable material, and tells how to manipulate the paper by putting it under strain and pressure. The claims that he made were as follows:

"First. An incandescent conductor for an electric lamp, consisting of a filament of carbon of relatively high resistance, substantially as hereinbefore set forth.

"Second. An incandescing conductor for an electric lamp, consisting of a filament of flexible carbon, substantially as hereinbefore set forth.

"Third. An incandescing conductor for an electric lamp, consisting of a filament of relatively high temperature and flexible carbon, substantially as hereinbefore set forth."

I have emphasized the word "flexible" because, while that condition is here specified, yet it is the testimony of plaintiff's witnesses that whenever you make a filament of carbon under the patent in suit it is flexible as a matter of necessity. They read the work flexible into the patent in suit. It was not necessary on their theory to employ the word here. In that respect there is no distinction to be made between the two cases.

The fourth claim is:

"Fourth. An electric lamp for giving light by incandescence, consisting of a filament of high resistance and flexible carbon, hermetically sealed within an inclosing globe made entirely of glass, substantially as hereinbefore set forth."

The Patent Office rejected the application upon the ground that the claims are not found to present anything patentable in view of the patent to applicant of Jan. 27, 1880. That is the patent in suit. They did not take the rejection graciously, but said in answer:

"The claims presented in this case cover matters of substance, the vital improvements and advances in the art which have been made, or have at least been prominent factors in making Mr. Edison's system the success it is. His inventorship in the premises has not been disputed, and he is entitled to protection therefor.

"Under the late rulings of the Supreme Court Mr. Edison cannot obtain valid protection therefor by the reissue of his patent 223,898.

"The invention covered by that patent, viz., a certain incandescent electric lamp, does not form the essential features of the invention, such as is now specifically claimed.

"Under the practice of the office, following the decisions of the court, we are entitled to a separate patent for the matters of invention not claimed in a prior patent, even though such matters might be suggested by or inferred from the prior patent."

Later on Mr. Edison amended his application by introducing a paragraph relating to the mode of exhausting his lamp globe, and also describing for the first time the application of electrical heating on the pump. Some new claims were substituted for the old ones. In January, 1883, Mr. Dyer became attorney for the application and filed an entirely new specification and a new set of claims. In that specification he says, among other things, putting these words in Mr. Edison's mouth:

"In my patent, 223,898, is described one method of carrying out the principal parts of this invention, which method is herein"—I think that should be therein—"claimed; but the invention herein is anterior to the specific means of the said patent, and consists broadly in constructing an incandescing electric lamp with a hermetically sealed chamber entirely of glass inclosing an incandescing conductor of carbon and maintaining the conditions, whether of vacua or of an inert gas, existing within the inclosing chamber at the time of sealing."

That is precisely the scope which they now seek to impose upon the present patent. At that time, in January, 1883, Mr. Dyer supposed that the patent in suit was a narrow patent, limited to the specific means that are therein described, and that he was entitled to obtain for the Edison company this broad claim in the pending application, and the actual claim that was formulated by Mr. Dyer at that time was in these words:

"1. An electric lamp giving light by incandescence, consisting of a hermetically sealed chamber entirely of glass and a carbon conductor inclosed by the same, substantially as set forth.

"2. An electric lamp giving light by incandescence, consisting of an hermetically sealed glass inclosing chamber and an incandescing conductor inclosed by the same, composed of a flexible carbon filament, substantially as set forth."

A few words now with reference to the only remaining point bearing directly on the main question involved—the merits—and then I shall with the greatest of pleasure yield to my associates.

Our contention in regard to the patent brought here for adjudication is that it does not meet the stern requirements of the patent law. Mr. Edison did not in this patent describe the invention that he had made in such full, clear, exact and concise terms as would enable a person skilled in the art to make, use and construct and manufacture the same; nor did he describe the best mode in which he had contemplated applying the principle characterizing his invention; nor did he particularly point out and distinctly claim, as required by section 4,888 of the revised statutes, the things which he claimed to be his invention or discovery. I, of course, need not refer *in extenso* to what we hold with regard to the utter indefiniteness of the term "filament" which seems to be the pivot around which the whole patent revolves. It was a term new to the art, as everybody concedes, and we think there is absolutely no definition of the term in the patent, and complainant's experts have shown themselves to be utterly incompetent to define it.

Passing from this point I come to consider for a moment the meaning of the word "carbonization" in this patent; and I ask especial attention to it, because the patent has not undertaken to specify what that term signifies, and the testimony would go to show that in Mr. Edison's mind the term at the date when he took out this patent signified something not known to the art.

Therefore we come down to this point: We say that upon the testimony of Prof. Thompson, upon the experiments made by Mr. Howell for the plaintiff, it stands here practically confessed by the Edison company that it is impossible under this patent to make the thing which is described without resorting to practices not known to the art at the date when the patent issued.

Now I think, if I may be pardoned a word or two further, that not only does this pending application and its history throw a bright light upon the proper interpretation to be put upon this patent, but it throws a strong side light upon the laches of the plaintiff in bringing suit under patent 223,898. I a little while ago referred to the competition that was going on between the United States company and the Edison company from the very beginning almost of 1880 down to May, 1885, when this suit was filed. They looked on and said nothing. They commenced no proceeding. Major Eaton says the reason was that we were not doing them enough harm. Now that is simply childish. It does not commend itself to my conception of what is reasonable. The explanation of that delay, your Honor, is to be found right here in the history of that pending application. The Edison company did not believe during those years that this patent now before the court was the fundamental patent which they at present assert it to be. They went to the Patent Office and were there contesting, with all the vigor that they could bring to bear upon the question, their right to secure a broad claim coextensive with what they now declare to be the meaning of this patent 223,898. They said they had not got such claims in that patent; they said it was a limited patent; they said furthermore that it did not cover the invention that was made by Mr. Edison; and they said that it could not be reissued; and because they had not covered the invention made by Edison in that patent, and because they could not reissue the patent, even though his broad invention, according to their contention, was described therein, they said they had a right to take another patent, and that is what they are seeking to do; and it would be a stultification, in regard to that position during that controversy, to have come to this court, or any other court with patent 223,898, and said "That is a broad and fundamental patent." They did not bring suit under this patent, your Honor, until that application in the Patent Office had drifted into that position where they felt powerless to secure what originally they asserted under it to be their rights. When they found themselves in that position—when they found themselves unable to do anything more than merely keep the breath of life in it and the record shows that at that point they stopped for almost a whole year without lifting a finger in regard to it; that was because it seemed to them a hopeless case—when the application had drifted into that position, and they found themselves unable to cope with the arguments that were presented against the application, then they said "We have nothing to lose by taking our chances on the patent 223,898." That is the explanation, and the only explanation, of the delay to bring this suit against this company under the patent now presented to the court.

The National Electric Light Association.

The Executive Committee and the Committee on Exhibits of the National Electric Light Association met at the Windsor hotel in Montreal on the 8th inst. to arrange the details of the coming convention and exhibition to be held in that city in September next. These committees received a most enthusiastic and cordial welcome from the mayor and representatives of the common council, and also from a deputation from the Citizens' Committee organized in Montreal for the purpose of carrying out the plans for the reception and entertainment of the association during the convention. The mayor and Alderman Stevenson represented the city government, and ex-Mayor Beaugrand the French Canadian population.

The Executive Committee for the reception of the association was represented by Profs. Bovey and Cox, of McGill University, and Mr. John Carroll, of Montreal. Prof. Cox, as secretary, read the report of his committee, which was as follows:

MONTREAL, June 8, 1891.

The committee has held three meetings. A Reception Committee is being formed which already includes a large number of the most influential citizens of Montreal.

His Excellency, the Governor-General, has signified by letter that if the visit of the Association takes place in September, he hopes to be present, but under any circumstances will be glad to give his patronage to the meeting.

A number of plans for offering entertainment to the Association have been considered, but the final adoption must depend upon the date adopted for the visit, and the programme of the Association. Among the suggestions already considered by the committee are plans for a citizens' ball, a lacrosse match, an excursion to the Rapids, drives around the mountain, a promenade concert at Solmer Park, visits to the G. T. R., C. P. R., and Dominion Bridge Works.

A Press Committee and Ladies' Committee will be formed, and special entertainment provided for the ladies of the association.

The officers of the Executive Committee, with Mr. John Carroll, were instructed to wait upon the executive of the association on June 8, and convey to them a cordial welcome to Montreal.

This report was received, and adopted with suitable expressions from President Huntley and the members of the Executive Committee, of their deep appreciation of the hospitable action of the Citizens' Committee. The meeting then adjourned, and the Executive and Exhibit committees held a preliminary meeting for the purpose of organization and the discussion of ways and means. The Executive Committee fixed definitely upon Sept. 7 as the opening day for the convention, the exhibition to be held from Sept. 7 to 16, inclusive.

The powers of the Exhibit Committee were defined, and arrangements made for the prosecution of detail work by the Exhibit Committee at their next meeting.

On the following day the adjourned meeting of the Exhibit Committee and also the adjourned meeting of the Executive Committee were held at the Windsor Hotel.

At the Exhibit Committee there was a full attendance, the following named gentlemen being present: C. R. Huntley, president of the association; F. R. Redpath, of the Redpath Refinery; Profs. Bovey and Cox, of McGill University; M. D. Barr, of the Edison Company in Toronto; W. J. Morrison, Ft. Wayne Electric Company; Fred Nicholls, of Toronto Incandescent Electric Light Company; H. H. Fairbanks, of Worcester (Mass.) Electric Light Company; E. F. Peck, Citizens' Electric Illuminating Company of Brooklyn; J. W. Beane, secretary and treasurer of the association; S. C. Stevenson, Council of Arts and Manufactures, Montreal; A. J. Corriveau, Canadian Electrical Construction, Manufacturing and Supply Company; and John Carroll, Eugene Phillips Electrical Works, Montreal.

Among other things it was decided to hold the exhibition open each day and evening, during which time all the appliances are to be in motion.

It is expected that this exhibition will be the most interesting, as also the largest, yet held in the interests of electricity in America, if anything can be judged from the enthusiasm shown by the electrical fraternity, and also by all the largest electrical companies, who have already applied for large spaces. From the applications for space already made, it is believed that if the Victoria Skating Rink were twice the size it could be well filled. It is proposed, in anticipation of there being insufficient space, to erect, on the vacant ground adjoining the rink, a large tent which has kindly been offered to the committee by Mr. S. C. Stevenson for the purpose.

A local sub-committee was appointed to co-operate with the chairman of the Exhibit Committee, J. I. Gulick, for the different arrangements in connection with the exhibition, composed of F. R. Redpath, chairman, Prof. Bovey, Prof. Cox, Fred Nicholls, S. C. Stevenson, A. J. Corriveau and John Carroll. At the Executive Committee's meeting a large amount of important business was transacted, one of the questions discussed being the papers to be read at the convention.

The prospects for a successful meeting of the Association and an elaborate display of apparatus are certainly all that could be desired. It is said that several of the large electrical companies have applied for a space sufficiently large to display to good advantage the goods which they are desirous of placing on the Canadian market. One prominent company has, it is asserted, made application for 5,000 square feet of space, and several other smaller companies propose to make exhibits proportionately large.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

The Closing Quotations of electric stocks, from F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, on Saturday, June 13, 1891, in New York, Boston and Washington, and in Pittsburgh, June 13, were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80½	81
American Telegraph & Cable	100	14,000,000	....	80¼
Central and South American	100	5,000,000	135	142
Mexican	100	2,000,000	200	215
Commercial Cable Co	100	7,716,000	105	106½
Postal Telegraph Cable	100	5,000,000	30	32
Edison General Electric Co	100	9,503,500	99	102
" " Deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929,400	....	....
Edison Electric Illuminating Co.	100	2,567,800	76	....
United States Electric Light	100	1,500,000	30	....
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	42⅝	43½
" " preferred	25	4,000,000	25	....
" " Series C	10	400,000	....	....
" " Series D	10	120,000	7	7¼
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1 000,000	....	....
" European Welding Co	100	1,000,000	....	60
Ft. Wayne Electric Co	25	4,000,000	12	12¼
Detroit Electrical Works	..	....	....	....
Westinghouse Electric Co	50	5,000,000	12⅞	13¼
Telephone:				
American Bell	100	12,500,000	198	200
Erie	100	4,800,000	48	48⅛
New England	100	10,304,600	50	....
Mexican	10	1,280,000	1.25	1.30
Tropical American	10	400,000	90c.	....
Edison Phonograph Doll	10	1,000,000	50c.	1.00
WASHINGTON.				
Pennsylvania Telephone	50	750,000	24	....
Chesapeake & Potomac	100	2,650,000	62	65
American Graphophone	10	600,000	5¾	7
United States Electric Light (Washington)	100	300,000	155	160
Eckington and Soldiers' Home Electric Ry	50	352,000	49½	....
Georgetown and Tennallytown	50	200,000	57	65

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$240	Cumberland	$60@ $62
Central Union	54@ 55	Wisconsin	118@ 120
Michigan	84@ 85	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$163@$104	Chicago Edison Co	$145@$150

Mexican Telephone.—It is rumored that the capital stock may be cut down by issuing one share for 10, per to be made $100, and that dividends will be paid. A reduction of the capital stock to at least $500,000 would make the stock much more popular than it now is with its nominal valuation of $2,000,000.

Thomson European Electric Welding.—At the annual meeting at Portland, Me., last week, the following named directors were chosen: Oliver Ames, Benjamin F. Spinney, George P. Meserve, S. Endicott Peabody, Henry D. Hyde, Prentiss Cummings, Joseph N. Swett, Royal G. Robbins and Francis Peabody, Jr.

The Bell Telephone Company has declared a regular quarterly dividend of three per cent., and an extra one of six per cent., both payable July 15 to stockholders of record June 30. The transfer books will be closed from July 1 to 15, both days inclusive. It requires nearly $1,350,000 to pay this dividend, and presupposes enormous earnings for the year.

Westinghouse.—The Westinghouse reorganization committee offers the stockholders of the Consolidated Electric Light Company, subject to the success of the general reorganization, opportunity to exchange their stock for 25 per cent. in the Westinghouse 7 per cent. preferred stock and 50 per cent. of the Westinghouse common "assenting" stock provided for in the plan of reorganization. The Westinghouse Company now leases the Consolidated Company, but announces its inability to meet the rental. Over 80,000 shares of Westinghouse stock have been deposited under the reorganization plan.

Thomson-Houston.—In regard to the two bills in equity filed in the United States Circuit Court, brought by the Sprague Electric Railway and Motor Company, and the Edison General Electric Company, against the West End Street Railway, for alleged infringement of patents held and controlled by both corporations, Mr. Robert Clapp, attorney for the Thomson-Houston Electric Company, is quoted as saying that the Thomson-Houston Company will have to defend the West End Company in this suit. He says that the Thomson-Houston Company has made an agreement with the West End Company, as it does with other companies using its patents, to defend any suit brought against it for infringement for using any apparatus furnished by the Thomson-Houston Company. The Thomson-Houston Directors recently organized, and no change from previous years' officers was made, with the exception of the resignation of Director F. P. Fish. He was succeeded by Capt. Griffin, who was elected second vice-president. The office of third vice-president has not been filled.

Western Union stockholders will receive the usual quarterly dividend of 1¼ July 15. The books close June 20 and reopen July 2. The approximate operations for the quarter ended June 30 are reported as below:

Quarter June 30, 1891.	1891.	1890.	Decrease.
Net revenue	$1,500,000	$1,750,000	$25,000
Interest and sinking fund	242,898	243,143	245
Balance	$1,257,102	$1,506,857	$249,755
Dividend	1,077,400	1,077,395	*5
Surplus	$179,902	$429,462	$249,760
Total surplus	11,325,078	10,020,377	*1,307,701

The Western Union company's fiscal year ends June 30. The approximate report for the year shows thus:

Year June 30,	1890-91.	1889-90.	Decrease.
Net revenue	$6,556,434	$7,320,073	$763,639
Interest and sinking fund	971,737	955,091	*16,646
Balance	$5,584,697	$6,364,982	$780,285
Dividends	4,309,701	4,956,004	646,303
Surplus	$1,274,996	$1,408,978	$133,982

* Increase.

The telegraph service was about $300,000 larger during the quarter than for the same period in 1890, but the damages to the main building by fire and the cost of repairing storm damage, as well as decreased rentals for private wires, rentals of buildings, the commercial news service, etc., have made a smaller net in both ;

March 31 and June 30 statements. These are the reasons why the net March 31 was $173,319 under the estimate. At the directors' meeting last week, President Green stated the number of stockholders now was 4,642, an increase of 800 over last year. This is the largest number of stockholders the company has ever had. He estimates that there are about 170,000 shares in the names of brokers, the balance being in investors' hands.

AFFAIRS OF THE COMPANIES.

The Consolidated Gas and Electric Light Company, of Portchester, N. Y., has been sold at foreclosure sale for $25,000. The original cost of the plant was over $250,000.

The Brookline Gas-Light Company, operating the Westinghouse system, has declared its regular semi-annual dividend of 3½ per cent. payable July 15 to stockholders of record of June 30.

The Detroit (Mich.) Electrical Works has purchased through E. C. Van Husan 16 acres of land with a frontage of over 400 feet on the Grand Trunk Railroad, in Detroit. The property will be used for a mammoth plant to cost $150,000 to $200,000 and to employ 1,000 men.

The Franklin Telegraph Company, of Boston, Mass., at its last annual meeting elected the following directors and officers: John Van Horne, Norvin Green, T. T. Eckert, C. A. Tinker, A. R. Brewer, J. F. Greenough, G J. Gould, F. L. Ames and Thomas Roche; R. H. Rochester, treasurer; Thomas Roche, clerk.

The Southern New England Telephone Company at its recent annual meeting reported the receipts for the year to have been $336,467.19 from all sources. The company paid out over $83,000 for rentals and royalties, yet had a revenue balance o over $78,000, showing an increase in the income of over $22,000. The earnings are still applied to the extension of the plant. The new building in Hartford has been built and equipped and an underground system containing 39,758 feet of cable established; this work has cost over $57,000. The monthly average of subscribers has been 5,500.

The Erie Telegraph and Telephone Company held its annual meeting recently and elected the following directors: Abner S. Adams, Charles E. Adams, Charles J. Glidden, Francis Jewett, James W. C. Pickering, A. C. Russell and Levi Sprague, of Lowell, Mass.; Wesley A. Gore, of East Boston; James A. Weston, of Manchester, N. H.; Harvey A. Whiting, of Wilton, N. H.; Arthur L. Andrews and George W. Steadman, of Albany; Thomas M. Bartlett, Henry D. W. Burt, Edward W. Carritt, Henry C. Dodge, William Q. Riddle, Henry P. Sewall, Horace H Smalley, William G. Smythe and H. Frederick Stevens, of New York. The directors organized by electing Levi Sprague as president, Charles J. Glidden secretary and treasurer, and James P. McKinstry general manager. The stockholders of the Southwestern Telegraph and Telephone Company, one of the Erie's sub-companies, then met and elected the following directors: Charles E. Adams, Charles J. Glidden and Levi Sprague, of Lowell, Mass.; Thomas Sherwin, of Boston; Arthur L. Andrews, of Albany; David B. Parker, Henry P. Sewall, Horace H. Smalley and H. F. Stevens, of this city. The directors elected Mr. Sprague president and Mr. Glidden secretary and treasurer.

NEW INCORPORATIONS.

The Willapa Electric Company, of South Bend, Wash., has been incorporated, with a capital stock of $100,000.

The Winters Electric Company, of Chicago, Ill., has been incorporated, with a capital of $10,000, to manufacture electrical appliances. The incorporators are F. M. Winters, A. F. Raymer, A. H. Baldwin.

The Elwood (Ind.) Electric Light and Power Company has been incorporated, with a capital stock of $10,000, to furnish electric light and power. The directors are Cassius M. Greenlee, Volney Q. Irwin, Jacob Loomis and Charles A. Gates.

The Commercial Construction Company, of Portland, Ore., with a capital stock of $30,000, has been incorporated. This company will operate an electric light plant in Portland. J. P. Marshall, C. D. McLaine, J. F. Barrett, and J. C. Band are the incorporators.

The Moravia Electric Light, Heat and Power Company has been incorporated at Moravia, N. Y., with a capital of $20,000. Among its incorporators are Wm. Selover, E. M. Benton, F. C. Reynolds, Wm. J. H. Parker and Wm. Fitts. The above named company is ready to receive bids for lighting purposes.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, June 15, 1891.

Mr. C. E. Newton, secretary and treasurer of the Jewell Belting Company of Hartford, was in New York this week on a business trip.

Mr. David Chalmers, of the A. B. C. Company, has just returned from a trip through New York State which has been unusually successful, and reports that there is every prospect for a large trade during the balance of the year.

Mr. Burton, who has had charge of the electrical department of the Ansonia Brass and Copper Company in New York, has resigned, and leaves for England in a few days. Mr. E. T Foote, for some years with this company and well known to the electrical fraternity, will succeed him.

The Jewell Belting Company, of Hartford, Conn., has opened offices in New York at rooms 209 and 210, Electrical Exchange Building, with Mr. C. E. Ainsworth in charge. This company has just installed the belting for the new Edison shops of the Northern Pacific Railroad, Tacoma, Wash.

Mr. Louis Walsh, in charge of the battery department of the A. B. C. Company, reports that orders have been so large for its new dry battery that the company is unable at present to meet the demand. The new porous cup, just introduced by this company, has also been received by the trade with distinct favor.

The Hall Signal Company held its annual meeting in Portland, Me., on June 10th. Mr. Wm. P. Hall was again elected president, Mr. W. S. Gilmore treasurer, and Mr. A. A. Stroat clerk. The old board of five directors was also re-elected. The report of business during the past year was very satisfactory and the outlook for the future exceedingly promising.

Messrs. Charles A. Schieren & Co., of New York, have just shipped to the West End Street Railway, of Lancaster, Pa., two 22-inch double and three 16-inch double perforated belts; to the Terre Haute Ind.) Street Railway Company, one 24-inch double perforated belt; to the Edison Illuminating Company, of Detroit, Mich., two 20-inch double, perforated electric belts.

The McCreary Electrical Specialty Company, of 136 Liberty street, New York, has arranged with the Pettingell-Andrews Company, the Holtzer-Cabot Electric Company and the Thomson-Houston Electric Company to handle exclusively their well-known specialties throughout the New England States. The above houses will have a complete stock at the lowest prices.

A Smoking Concert will be given at the Electric Club, Thursday evening, June 18, at eight o'clock. This is the first entertainment of the kind attempted by the club, and it is believed that the occasion can be made a very enjoyable one. Members will contribute to the programme, which will include several original and novel productions. A business meeting of the club will be held after the smoking concert.

Columbia College Degree of E. E.—The first class to receive the degree of electrical engineer graduated at the commencement, June 10. The students to receive the degree were: Gano S. Dunn, B. S.; Wm. H. Freedman, C. E.; Arthur S. Ives, C. E.; Joseph T. Monell, C. E., and Robert B. Owens. These were postgraduate students, all having received a thorough collegiate education and then a two years' course entirely devoted to electrical engineering work. The plan has been found to give most excellent results.

Mr. W. J. Morrison, general agent of the Ft. Wayne Electric Company, has just sold to the Ogdensburg (N. Y.) Gas Light Company a 750 light Slattery machine; he also sold a 120 Wood arc light machine within the past few days. Mr. Morrison was one of the committee of the National Electric Light Association who visited Montreal last week for the purpose of arranging for the coming convention. He is very enthusiastic over the reception received by the delegates and says it will be the greatest convention ever held since the organization of the association.

Lighting and Ventilating the Tunnel.—The State Railroad Commissioners have received from the Edison Electric Illuminating Company a long letter on the subject of illuminating and ventilating the New York Central Fourth avenue tunnel, in which, after stating in detail the difficulties of the task, and declaring that the number and weight of trains passing through the tunnel were greater than in any other tunnel in the world, the company said: "The use of electric current for the purpose of actuating ventilating fans along the line of the tunnel will reduce the difficulties of this problem to a minimum. Fans actuated by electric current can be placed at varying distances from each other and in any position that may be rendered necessary or convenient for the purpose of connecting with ducts of varying size, according to the necessities of construction and the amount of space available at different points. Electric power from the Edison low-tension system can be supplied from the same lines used to furnish current for the lamps required to light the tunnel. . . . By the use of low-tension electric motors in connection with electric light under the Edison system, the difficulties of the problem under consideration will be reduced to the minimum. We shall be glad, if afforded the opportunity, to furnish the necessary plans and specifications for your consideration." L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 8, Cook Building, cor. Franklin and Congress Sts.,
BOSTON, Mass., June 13, 1891.

The Thomson-Houston Motor Company has, it is claimed, 1,200 motors ordered ahead of its deliveries.

The Atlantic Covering Company, of Plymouth, Mass., is very busy. The factory is being run to its full capacity.

The Gloucester (Mass.) Electric Company has just purchased 20,000 feet of land, on which the buildings will be erected.

Quincy, Mass.—The Thomson-Houston system will be adopted for the Electric Freight Railroad. This road will be principally used for the transportation of granite.

The Haverhill (Mass.) Electric Light Company is to erect an entirely new plant, which the managers believe will supply the electric needs of Haverhill for ten years to come.

The Thomson-Houston Electric Company now employs at the Lynn, Mass., works 2,550 men and women, and it is expected that many more will be taken on the pay roll within a short time.

The Russell Electric Manufacturing Company, of Providence, R. I., is receiving some large orders for the celebrated "Russell" mast arm, and is increasing its facilities to meet the demand.

Mr. Pettingell, of the Pettingell-Andrews Company, has just returned from an extended European trip very much improved in health and greatly enlightened by what he saw abroad electrically and otherwise.

The Jenney Electric Motor Company, of Indianapolis, Ind has issued a pamphlet descriptive of the excellent motors manufactured by this company. The pamphlet also contains a price list of the company's apparatus.

Mr. Elliott O. Johnson, well known to the trade in New England and New York, will be united in matrimony to Miss Alice Bartlett Clough, on Wednesday, June 24, at St. Stephen's Memorial Church, Lynn, Mass.

The National Electric Company's anti-induction wire is being adopted by the fire alarm and police telegraph systems of this city after a thorough test by Superintendent Flanders. This action is a signal of the success in store for the National Electric Company.

Mr. J. Heilborn, president of the Beacon Vacuum Pump and Electric Company, sails the 18th inst. for Europe. Mr. Heilborn expects to visit places of interest in England, Germany and France and be absent several weeks. His many friends wish him bon voyage and a safe return.

The Electrical Specialty Company, of Pawtucket, R. I., has been incorporated for the purpose of manufacturing and selling electrical specialties. Mr. A. D. Ross is treasurer of the company, Mr. E. B. Crocker, president, and Fred H. Angell, traveling salesman. It goes without saying that their success is assured from the start.

Salem, Mass.—At a meeting of the Essex Electric Railroad Company recently, F. W. Standley resigned as a director, and Mr. O. E. Norcross was elected to fill the vacancy, and was subsequently elected president in place of Mr. King Upton, who has been president since the organization of the company. J. H. Fallen resigned as treasurer and F. E. Farnham was elected to the position. It is said that Mr. Norcross has purchased a controlling interest in the road and will operate it.

Worcester, Mass.—Negotiations have been begun by the Worcester Electric Light Company and the Street Railway Company for supplying power by the former company for the new street car line to the lake. If an agreement is arrived at the Electric Light Company will put in a new 500 h. p. engine at its works. Preparations are now being made to put in two new 50 arc light dynamos. This has been rendered necessary by the contract with the city, which calls for a number of new lights.

Messrs. J. E. Wilson & Co., of No. 8 Oliver street, Boston, report the sale of the following Rollins engines of Nashua, N. H.: Concord Street Railway Company, one 250 h. p. engine; J. E. Phillips, Carlisle, one 150 h. p. engine; Portsmouth Brewing Company, Portsmouth, N. H., one 60 h. p. engine; James Means & Son, Brocton, Mass, one 60 h. p. engine; Wacole & Co., Putney, Vt., one 60 h. p. engine; Whitman & Keith, Campbells, Mass., one 90 h. p. engine; Pickering Knitting Company, Lowell, Mass., one 90 h. p. engine; Gay Brothers, Cavendish, Vt., one 90 h. p. engine, and J. E. Mann, East Weymouth, Mass., one 90 h. p. engine, and have a number of other contracts pending, the most of which are for electrical purposes. This would indicate an improved condition of trade generally through New England.

Rockport, Mass., is in a turmoil over a petition by the Gloucester (Mass.) Street Railway Company for the location of an electric line in that village and the objection of the Commercial Cable Company to granting the same. The location asked for extends from a point in Gloucester, near Bass Rock, over Brier Neck to Land's End, past the famous summer resort, Turk's Head Inn, and down Court street, in this village, to Dock Square. Part of the way the line would be parallel with the Mackay-Bennett cable, which runs from Rockport to the station, on the Island of Canso, and would also pass near the cable company's terminal station at Rockport. The cable company claims that the presence of an electric current 600 times as powerful as that passing through the cable would seriously affect the workings of the delicate cable instruments. Superintendent Herne, of the latter company, says that in case the road were put in the cable company would have to go.

C. A. B.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, June 20, 1891.

Mr. J. M. Jackson, of the Western Electric Company, Chicago, has left for New York en route to Europe, where he will spend several months.

Mr. Herbert Wadsworth, of Chicago, manager of the Excelsior Electric Company, has sold a 100 light arc plant, complete, to the Minneapolis Street Railway Company.

The Western Electric Company, of Chicago, Ill., has made application for 10,000 square feet of space in the Electricity Building at the World's Fair. The Bell Telephone exhibit will probably adjoin this.

Mr. W. H. Harding, manager of the Central Electric Light Company, of Chicago, has gone east on a combined business and recreation trip, during which he will probably arrange for a considerable quantity of underground cable.

Mr. W. T. Bonner, well known among the steam and electrical people in the West, has entered the service of Fraser & Chalmers, with headquarters in Chicago, and will have charge of the department of electrical installations.

Mr. F. H. Weir, the Chicago representative of the Falls Rivet and Machine Company, Cuyahoga Falls, Ohio, has secured the contract for the clutches, line shafting and pulleys in the Masonic Temple electric light plant in Chicago.

Chicago Visitors.—Among the out-of-town visitors in Chicago this week are Thomas D. Lockwood, of the American Bell Telephone Company, Boston; S. A. Barton, president of the Brush Electric Company, Cleveland; D. R. Russell, Parker-Russell Mining and Manufacturing Company, St. Louis, and Chief Engineer Du Bois, of the Interior Conduit & Insulation Company, New York.

A World's Fair Medal.—Messrs. J. J. Ryan & Co., of 1 West Monroe street, Chicago, are sending out with their compliments some handsome specimens of their work in the form of medals which can be utilized as paper weights, sleeve buttons or even street car wheels. The face of one bears an excellent likeness of Christopher Columbus and the other that of Queen Isabella.

Transferred to a Trust Company.—The Brush Electric Company, of Cleveland, O., has quitclaimed its entire plant to the Old Colony Trust Company for the nominal consideration of $1. The transfer was made to secure a series of first mortgage bonds for $500,000, which were issued to indemnify the minority stockholders, who were not satisfied by the recent transaction through which the corporation was absorbed by the Thomson-Houston Electric Company.

Out of Town Visitors.—Among the visitors to Chicago during the week are Mr. Geo. F. Card, of the Fort Wayne Electric Company, Fort Wayne, Ind.; Clarence A. Ross, the Kansas City representative of the Thomson-Houston Electric Company; Frank H. Putney, manager of the Waukesha (Wis. Electric Light Company; Messrs. Pfatischer and Register of the Accumulator Company, New York; and Prof. W. G. Oldfield, of the Newton (Kan.) Electric Light Company.

Electric Carbon Trust.—A St. Louis carbon candle manufactory, in a circular letter, inform its customers that it has reason to believe that a combination of electric carbon manufacturers has been formed. The trust, it is said, is composed of the National Carbon Company, of Cleveland, which recently bought the Bolton works after an assignment; the Standard, the Brush and the Thomson-Houston companies, also of Cleveland, and the Fidelity Carbon Manufacturing Company, of St. Louis. It is believed also that the Faraday Carbon Company is in the trust. F. DE L.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Limit of Magnetization.—(1) What is the limit of magnetic density in cast and wrought iron cores? (2) What is the voltage and resistance of the telephone magneto machines? T. H. R.

(1) We would refer you to Thompson s "Electromagnet," page 72, for a full treatment of the hackneyed question. (2) You must write to the makers of the instruments for information.

Electromotive Force and Resistance.—Is the resistance of a wire the same when conducting currents of different E. M. F.? N. A.

For the same current, yes.

Electroplating.—Kindly inform me if I can use for electroplating a shunt dynamo wound for 158 volts and 30 ampères. What book can you refer me to? T. S. P.

Any current will electroplate, but it would be more practical if your machine were wound for 30 volts and 158 ampères. "The

Electroplater's Handbook," by Bonney, will give you the information you desire.

Repairing Armatures.—I have a 600-light armature in which the wires of three segments are loose. The ends of the segments are covered with shellac, which had melted out of the cap which secures the strips. Had I better scrape the ends of all the segments so filled before replacing the wires? Would shellac short-circuit enough to cause heating? J. H.

Shellac has never been known to *short-circuit* even a machine of Sir Armstrong's imagination, and it occurs to us that a good rule to follow in reassembling any apparatus is to make everything as it was when it left the factory. You speak of the shellac of the cap. If it belongs to the cap it does not belong to the segment ends. Take it off.

News of the Week.

THE TELEGRAPH.

Pt. Chautauqua, N. Y.—The Western Union Company is to open an office here June 25.

La Crosse, Wis.—The lines of the North American Telegraph Company are being equipped with the Patten multiplex system.

Idaho Lines.—The Western Union Telegraph Company operates in Idaho 846.41 miles of wire, valued at $62,356 The increase of line installation in the West has been something phenomenal during the last three years.

North Carolina Lines.—The Postal Telegraph Company is at work connecting one of its Wilmington wires with a through wire at Raleigh. When completed the company will have a direct wire between Wilmington and New York.

New Western Lines.—The Postal Telegraph Company will carry its lines west during the present summer, running into the mountains from Colorado Springs by way of Leadville, Glenwood, Aspen and Grand Junction to Salt Lake City. Competition always brings a more prompt and satisfactory service, and the people of western Colorado are to be congratulated accordingly.

THE TELEPHONE.

Bloomington, Ill.—The telephone system is at last to be renovated; new lines, instruments and batteries will be installed. The work is under the supervision of Manager Brakel, who deserves much credit for the manner in which he has operated the old system. The total amount allowed by the district superintendent at Springfield, Ill., for the improvement of the plant at Bloomington is $14,886.21. This includes $1,688 for new poles, $3,730 for 144 miles of new copper wire, $1,073 for a new switchboard, $400 for remodeling and repairing the office rooms and $5,160 for labor, etc.

Northwestern Systems.—Mr. P. G. Reynolds, Superintendent of Construction for the Northwest Telephone Exchange, has just returned to St. Paul, Minn., from a northern trip. Mr. Reynolds' trip included a visit to Michigan, where he purchased 700 poles for the reconstruction of the Fargo, Dak., and Moorhead, Minn., lines for a toll line from Fargo to Casselton, Dak., a distance of 21 miles, to afford communication from Mapleton, N. Dak., to Casselton. He then went to Grand Forks to look over the ground and make arrangements for connection between East Grand Forks and Grand Forks, N. Dak. The use of the telephone is growing very rapidly in these Northwestern towns. Grand Forks has now 83 subscribers, and this number will be materially increased when the line is run into East Grand Forks. During last month 21 new subscribers were added in Fargo, and the Fargo and Moorhead Exchange now numbers upward of 230 subscribers.

THE ELECTRIC LIGHT.

Jacksonville, Ill.—The Insane Asylum is to have a $15,000 electric light plant.

Omaha, Neb.—The contract for the new municipal electric light plant will soon be let.

Wheeling, W. Va.—The C., L. & W. railroad has adopted electric lights for the section at Wheeling.

Martins Ferry, W. Va.—The arc machinery at the electric light plant will be ready to start by the 15th inst.

Halletsville, Tex., has advertised for a municipal electric light plant, and will erect the station this summer.

Washburn, Wis., has advertised for bids for an electric light plant, and expects to have the town lighted at an early date.

Little Falls, N. Y.—The Board of Trustees have adopted a resolution to supply the village, bids to be received until June 30.

Colorado City, Col.—The electric light plant will be in full operation this week for the first time. This station is one of the most finely equipped in the West.

San Antonio, Tex.—Bids will be received until June 24 for the installation of an electric light plant for the Southwest Texas Insane Asylum, by Messrs. Larmour & Watson, of Austin, Tex.

Indianapolis, Ind.—The Board of Public Works held a session last week, and discussed specifications for the lighting contract. Bids will be asked upon 750 lights, for overhead and underground systems, and upon a ten years' contract, with the right to purchase at the expiration of that time retained by the city.

Shippensburg, Pa., has contracted with the Shippensburg Electric Light, Heat and Power Company for seventeen 2,000 c. p. arc lamps at $70 per lamp per annum, moon schedule, to 12 o'clock, and as many as necessary of 32 c. p. incandescents at $18 per lamp per annum. The contract is for three years from Oct. 1, 1891. The city has at present 650 incandescent lights in operation.

The Arnold Electric Manufacturing Company, of Chester, Pa., has recently made the following installations of Arnold dynamos and motors: One 400-light incandescent plant to the Thackera Manufacturing Company, of Philadelphia; one Arnold search-light plant on board S. S. "Eastern Shore," at Baltimore, Md.; one 150-light incandescent plant, including one search light, on board S. S. "Pocomoke," at Baltimore, Md. The company also built the steam apparatus for this latter plant.

The Thomson-Houston Electric Company reports the recent sales of the following apparatus for arc plants: Athens, O., 18 lights; Braintree, Mass., 30 lights; Chehalis, Wash., 30 lights; Bridgeport, Conn., 45 lights; Portland, Me., 45 lights; Brooklyn, N. Y., 90 lights: Narragansett Pier, R. I., 30 lights; Harrison, O., 35 lights; Ashland, O., 70 lights; Findlay, O., 45 lights; Springfield, Vt., 35 lights; Anderson, Ind., 50 lights; Salem, Va., 100 lights; Athol, Mass., 25 lights; Poughkeepsie, N. Y., 50 lights; Beverly, Mass., 100 lights; North Tonawanda, N. Y., 100 lights; Lancaster, O., 50 lights; Corning, N. Y., 50 lights; Camden, N. J., 50 lights; Lexington, Ky., 50 lights; Catlettsburg, Ky., 50 lights; Lockport, N. Y., 50 lights; Noblesville, Ind., 50 lights; Clinton, Ia., 50 lights; Parkersburg, W. Va., 100 lights; Lincoln, Neb., 150 lights; Washington, D. C., 100 lights; Put-In-Bay, O., 50 lights; Bay City, Mich., 150 lights; Syracuse, N. Y., 50 lights; Newton, Mass., 50 lights; Columbus, O., 50 lights; Covington, Ky., 50 lights; Newark, N. J., 100 lights; Elwood, Md., 50 lights; Key West, Fla., 50 lights; Oakland, Cal., 50 lights. Incandescent plants: Narragansett Pier, R. I., 1,300 lights; Springfield, Vt., 650 lights; Salem, Va., 1,300 lights; Newton, Mass., 650 lights; Key West, Fla., 1,950 lights, Titusville, Fla., 400 lights; New Haven, Conn., 400 lights; Bay Shore, L. I., 400 lights: Debellin, N. J., 300 lights; Shawnee, O., 300 lights; Akron, O., 1,300 lights; Camden, N. J., 1,300 lights: Brooklyn, N. Y., 1,300 lights; Lock Haven, Pa., 1,300 lights; Iron Mountain, Mich., 1,950 lights; Buena Vista, W. Va., 1,300 lights; Norwalk, Conn., 1,300 lights; Lexington, Ky., 1,300 lights; Atlanta, Ga., 1,300 lights; Waltham, Mass., 1,300 lights; Tacoma, Wash., 2,600 lights; Morristown, Tenn., 650 lights; White River Junction, Vt., 650 lights; New London, Conn., 650 lights; Patchogue, L. I., 650 lights; Martinville, Md., 650 lights; Princeton, Md., 650 lights; Bedford City, Va., 650 lights; Millersby, O., 650 lights; Milton, Mass., 650 lights; Cohassett, Mass., 650 lights; Catlettsburg, Ky., 650 lights; Waco, Tex., 1,950 lights.

THE ELECTRIC RAILWAY.

Athens, Ga.—The new electric railway is to be in operation this week. A test has been made of the installation of the station and everything has been found satisfactory.

Fort Dodge, Ia.—A company has been organized for the purpose of building an electric street railway. Local and foreign capital is interested. The City Council will hold a special session to consider the application for a franchise. If the franchise is granted as asked the road will be built at once.

Lakewood, R. I.—The matter of having an extension of the electric road from Pawtuxet to Lakewood has again come before the town. A petition to the Union Railway Company, asking for the extension, was started a month ago, but the holder of it being slow about half the people here have not yet seen it. A petition asking for the same thing has been extensively signed on the Warwick side of the bridge in Pawtuxet.

Geneva, N. Y.—The board of trustees of the village has granted a charter for an electric road through the streets bordering on the beautiful Seneca Lake. A company has been organized, with Mr. O. J. C. Rose, president; E. N. Squires, vice-president, and E. A. Walton, secretary and treasurer. The enterprise and executive ability of these gentlemen is an assurance of a success for the company and a great help to the people of that village who favor rapid transit.

The McGuire Electric Motor Truck.—One of the best designed and constructed electric motor car trucks is the new No. 19 B form, manufactured by the McGuire Manufacturing Company, of 122 North Sangamon street, Chicago, Ill. Each side and each end of the truck frame is formed of a single piece of pressed steel, with a two-inch flange top and bottom, and firmly riveted together at their ends. This forms the completed truck frame, which is elastic in every direction and so proportioned that the strains in service are equally distributed upon every part of it. The McGuire apparatus is an acme of simplicity, strength and durability. The truck is fitted with a new form of brake which is of assistance in making electric roads equipped by the McGuire Company most efficient and safe in operation.

LEGAL NOTES.

Electric Traction Patents.—It is announced that the Edison General Electric Company has instituted legal proceedings against the West End Street Railway Company, of Boston, for alleged infringement. The patents under which suit is brought are those of the late Sprague Electric Railway and Motor Company, and cover, as is well known, many of the generally adopted features of the electric railway. The struggle is really with the Thomson-Houston company, of course, and promises to be both violent and prolonged. Before it ends much light will be thrown on the origin of electric traction.

Edison Sued by a Former Partner.—T. A. Edison has been sued by E. B. Welsh, of Boston, to recover $250,000 damages for an alleged half interest which the latter claims to have in all the inventions and improvements made by Edison in transmission of messages by telegraphy. This suit was brought in 1884 in the United States Circuit Court, and the plantiff claims that Edison made a contract in April, 1869, by which he agreed, in consideration of various sums of money which Welsh had loaned him, to experiment on the invention which he was at work upon for use in telegraphic transmission. At this time Mr. Edison was in the employ of the Western Union Telegraph Company in Boston, and the plaintiff was in the employ of the Franklin Telegraph Company.

PERSONALS.

Mr. Charles Van Depoele, of the Thomson-Houston Company, is in Chicago, Ill.

Mr. Herman S. Hering, of Philadelphia, has been appointed associate professor in mechanical engineering at Johns Hopkins University.

Prof. Alexander Graham Bell is to erect a fine mansion at Washington, D. C. It will be located on Connecticut avenue south of Dupont Circle.

Dr. Arthur F. Kimball, associate professor of physics at Johns Hopkins University, has resigned that position to accept the professorship of physics at Amherst College.

Mr. Byron Reed, a pioneer settler and telegrapher and the wealthiest land owner in Omaha, died last week. In his will he leaves a valuable piece of land upon which to erect a public library. His collection of coins is also left to that city, and he makes numerous charitable bequests, amounting in all to over $100,000.

Mr. Henry B. Hamel, of Havana, Cuba, is on a visit to New York City. He is the agent of the Tropical American Telephone Company in Havana, and introduced the first telephones in that city in 1878. He has placed a large order with the Tropical Company, and practically controls the telephone business in the Island of Cuba.

MISCELLANEOUS NOTE.

Another Application for the Subtle Fluid.—The latest window advertising scheme on Broadway, which has been most successful in attracting large crowds, consists in the arrangement of two brass knobs at the window ledge with the following placard: "Electricity no more subtle than our bargains. Take a free, harmless shock. We press the button. See our 40 cent bargains in neckties."

Industrial and Trade Notes.

D. C. Spruane, who represents the Star Electrix Company, of Philadelphia, in the South and West, reports large sales from Washington and Providence.

Messrs. W. H. Gordon & Co., of 115 Broadway, New York City, are now carrying a full line of Fletcher's specialties. They are also making a leader of the celebrated Sunbeam lamp, and wish all their friends to try it, as they have great faith in its merits.

The Illinois Electric Material Company, of Chicago, is advertising that it is selling a line of new goods at cost. If so, it will certainly afford contractors and construction companies an excellent opportunity to lay in a goodly supply of material. Wonder if we shall have bargain days in electrical supplies?

The Riker Motor Company, of York street, Brooklyn, is enlarging its present factory facilities by renting additional floor space in the building at present occupied by its works. When these changes are made it will have elaborate testing and winding rooms, and be prepared to fill orders more promptly than heretofore.

McLeod, Ward & Co., of 91 Liberty street, New York City, who have been established in their present quarters only since the early part of the year, are rushed with orders on the installation of Edison motors in the city and vicinity, and the sale of their spark arresters, hoods, etc., which they manufacture, is taxing their facilities to the utmost capacity.

The McCreary Electrical Specialty Company, of New York City, has arranged with the Toronto Construction and Electrical Supply Company to be its representative in Canada, and to that end the McCreary company placed a full supply of all its specialties with the Toronto company. Canadian customers can hereafter save excessive charges in transportation and delays in addition to the lowest factory prices.

A Test of Steam Separators.—Under the supervision of Mr. R. C. Carpenter, professor of experimental engineering at Sibley College, Cornell University, there has been just concluded a test to ascertain the efficiency of steam separators. A full report of the test, with drawings, showing results and percentages of efficiency obtained by the several competing separators, can be had free by addressing for same the Hine Eliminator Company, of 106 Liberty street, New York City.

The Universal Arc Lamp Company's business has already increased so largely as to require special factory facilities, which have been secured at 527 West Thirty-fourth street, New York. The present plant is taxed to its utmost to meet the demands. At a recent competition test in a contract of the Edison company for lighting the Jersey City Depot for the Jersey Central Railroad Company, the "Universal" arc lamp was shown to be superior to many others, and was accepted for the equipment.

The "Acme Link" and "Eureka Dynamo" Belts, made by the Page Belting Company, 16 Dey street, New York, are meeting with remarkable success for power transmission in electric lighting and street railway stations. Among recent orders filled by this company was one for the Hampton & Old Point Comfort Railroad Company, at Hampton, Va., where two 20-inch wide "Acme link" and several Eureka dynamo belts are running which are receiving the highest praise from the superintendent in charge.

The Arnold Electric Manufacturing Company, of Chester, Pa., of which Mr. Craig Arnold, the well-known electrical engineer, is president, is doing a very good business this year in the sale of its dynamos and motors and the "Arnold" search lamps. This company is soon to introduce something of a startler in the line of electric bells. The Arnold company is the sole agent for the "Packard" incandescent lamps in Pennsylvania, Maryland, Virginia, New Jersey, Delaware, the District of Columbia, and all marine installations throughout the world.

The McCreary Electrical Specialty Company received an order from Europe this week for 2,000 of its specialties, including 1,000 of its celebrated reflectors. These reflectors are now in use in every country in Europe, and will shortly be introduced into Australia. The company is also very busy in filling orders for Almond's patented flexible tubing, which is the only article of its kind on the market. The judicious management of the officers of this company is shown in the fact that at the present time their business is at least double that of one year ago, and constantly growing.

Mr. C. E. Bibber, general manager of the Consolidated Electric Manufacturing Company of Boston, passed through New York on a business trip this week. Mr. Bibber reported the sale of the Jack-Knife switches made by this company as something enormous. This company has just patented the new "C. E. M." insulating fixture joint, and wherever it has been shown it has met with ready and large sales. There are 48 men now in the company's employ and in a few days there will be at least 60, with the prospect of a larger increase if the present rush of orders continues.

The Bodifield Belting Company, of 26½ South Water street, Cleveland, O., claims to have a belt superior to other makes, for the reason that the belt is very pliable, and that the grain of the leather is left in a perfectly natural state; it is an entirely new process; the company avoids bordering the leather, and compressing the grain and fibres to get the solidity. The company gets the leather in perfect condition by the filling process, and by this process leaves it in a very pliable condition. The Bodifield company believes that for the heavy duty often required of electric light and railway plants double belting is the more economical. Two Bodifield belts 48 inches wide and 106 feet long, and six belts 25 inches wide, averaging 65 feet long, have been purchased by the East Cleveland Railroad Company.

The Triumph Compound Engine Company, of Cincinnati, O., reports the following recent sales: Three 125 h. p. valveless compound engines at Reading, Pa.; one 80 h. p. valveless compound engine at Natrona, Pa.; one 80 h. p. valveless compound engine at Rochester, N. Y.; two 60 h. p. valveless compound engines at San Francisco, Cal.; two 55 h. p. valveless compound engines at Richmond, Va.; one 50 h. p. valveless compound engine at Hamlet, Ga.; one 30 h. p. valveless compound engine at Covington, Ky.; one 30 h. p. valveless compound engine at St. Louis, Mo.; one 15 h. p. valveless compound engine at Natrona, Pa.; one 15 h. p. valveless compound engine at Bardstown, Ky.; one 15 h. p. valveless compound engine at St. Louis, Mo., and one 15 h. p. valveless compound engine at Laurens, S. C.

The Chicago and Electric Fixture Manufacturing Company, of 47-49 South Jefferson street, Chicago, is making a specialty of manufacturing to order any form of electric, gas or combination fixtures for the trade and is now turning out an extra amount of special work for the large supply houses. Mr. H. G. Willard, long and favorably known to fixture dealers from the Atlantic to the Pacific Coast through his connection with the Archer & Pancoast Manufacturing Company, is the president of the company, which he has well equipped to handle any reasonable amount of work, having nearly 100 men employed, including skilled designers and draughtsmen. The factory being complete in all its details, with furnaces, foundry for wrought iron work, spinning room, dippery, plating and laquering rooms, orders are quickly

filled, a feature of importance to electric light and street railway supply houses.

The Ball & Wood Company's new plant, Elizabethport, N. J., promises to be a model in equipment and convenience for building the improved Ball automatic cut-off engines. With a stretch of 900 feet between the main tracks of the Central Railroad of New Jersey and Trumbull street, with the Singer Park at one end and the railroad station at the other, it is an ideal manufacturing site. Two railroad sidings will serve: one the main machine shop through which it passes, and the other the foundry which at present is in contemplation. From the City Hall in New York to the factory station is exactly ten miles, and a long distance telephone will connect the points, placing purchasers of engines in instant communication with the source of supply. In the main machine shop even a wide-awake engineer will be impressed with the mechanical progress made in the last decade. A glance will embrace an enormous room, light and airy, 70 feet high to the roof, and flanked with wide and substantial galleries sustained by iron columns. Overhead a Shaw electric crane will noiselessly raise a completed compound engine of twenty tons from the testing block, carry it the length of the shop, and place it on a car in readiness for shipment. On either hand are new and massive tools the latest product of shops both East and West, and throughout the entire establishment an order of system prevails, which in itself will guarantee substantial and excellent work. It is the intention of the company to increase its plant by adding in length when it becomes necessary, and this can be done without interrupting the work in progress. A number of orders for the Improved Ball engines are already entered, and in another month the factory will be a busy scene, well worth the inspection of engineers as well as purchasers of this well-known engine.

New Works of the Crocker-Wheeler Electric Motor Company.—The establishment of the Crocker-Wheeler Electric Motor Company, West Fourteenth street, New York City, has been enlarged, and the alterations which have been going on for some time in the old portion of the works are completed. Access to the company's quarters is now furnished by a new entrance on West Fourteenth street. The staircase leads one to the exhibition room, which is well lighted and neatly finished in hard wood—a most interesting place. Here, if the weather be warm, an overhead ventilating fan furnishes a delightful breeze. This same motor, hardly larger than "a pint of peanuts," is also used to operate other fans of the same type in different parts of the establishment. A number of motors, ⅛, ¼, ½, ¾, 1, 3 and 5 h. p., are exhibited in connection with electric disc ventilating fans, electric pumps, etc. An interesting exhibit is a ½ h. p. motor which runs a sewing machine. Other applications noticed are a ⅛ h. p. motor driving a 2×1¾ inch triplex pump, and ½ h. p. motor driving a 1¼ × 2 inch triplex pump of the Gould Manufacturing Company's pattern. In the same room on a long table is also shown the Crocker-Wheeler motor dismembered, so that the various parts and stages of its construction can be readily understood and appreciated. To the right of the exhibition room is the office of Messrs. F. B. Crocker and S. S. Wheeler, a pleasant, well lighted and cozy room, nicely furnished with polished oak desks, chairs and other necessary office fixtures. It will also be used for board meetings. Next are the quarters of the secretary and general sales agent of the company, Mr. Geo. W. LaRue and Mr. W. H. Geers, the assistant secretary. The shops and testing-room are located to the left of the exhibition room, and run the entire length of the block between West Fourteenth and West Thirteenth streets, and are fitted throughout with the finest machinery obtainable, necessary for the company's manufacture. The company here employs about 150 hands—men and girls.

Eckert Interior Conduits.—Mr. Wm. H. Eckert, whose name is as well known as any other in connection with telegraph and telephone management, is now engaged in the manufacture of interior circuits for electrical and other work, in connection with the Eckert Electric Manufacturing Company, 54 New street, New York City. Concerning his work in this particular direction, Mr Eckert says: "My experience, extending over many years, and my knowledge of the tubes now upon the market, intended for that purpose, has enabled me, I flatter myself, to produce an article that is as near perfection as possible. I claim: (1) That every wire carrying an electric current inside of a building should be run through a tube; that telephone, telegraph and district messenger wires are just as dangerous, if unprotected by tube, as electric light wires. (2) That under no cirumstances, or with any alleged safeguards, should more than a single wire be run in any tube. (3) That every building now constructed or to be constructed should be tubed in preparation for the electric light, which is so fast supplanting gas, and that wooden molding, being inflammable, should not be allowed. I am thoroughly satisfied that as the insurance officials come to understand the subject more thoroughly they will require buildings to be so tubed, and all wires to be protected by tubes, or else consider buildings not tubed as extra hazardous risks. I claim that such tubes should have the following qualities, and I can guarantee that those manufactured by me fully come up to such a standard: (1) The tube should be fireproof, that is to say, it should be impossible for the tube to ignite if held in the flame of a Bunsen burner or gas jet; or, in other words, it should be impossible for such tube to conduct flame, but it should only char by being brought in contact with the flames referred to; or if subjected to a high enough degree of heat to cause it to flame at all, the flame should go out immediately upon the removal of the cause. (2) The tube should stand a test for insulation of not less than one megohn with a current of 500 volts. (3) The insulating compound should not melt or run, or be affected in any manner by being placed on or in close proximity to steam pipes where the temperature is say 400 degrees Fahrenheit. (4) The tube should be thoroughly moisture-proof.'

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

Intelligent people, who are familiar with the respective advantages which are offered by the several competing railroad lines between Chicago, St. Louis, and Kansas City, and who desire to travel with the utmost speed, safety and comfort, always take the popular and reliable Chicago & Alton Railroad between these points, and passengers going to or coming from the South, via St. Louis, or when going to or coming from the West, via Kansas City, should insist upon having tickets that read over the Chicago & Alton. It is the only road with three complete and elegantly equipped trains daily between Chicago and each of the points named, and no railroad managers in America have a more intelligent appreciation of the wants of the traveling public than do those of the famous Chicago & Alton.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

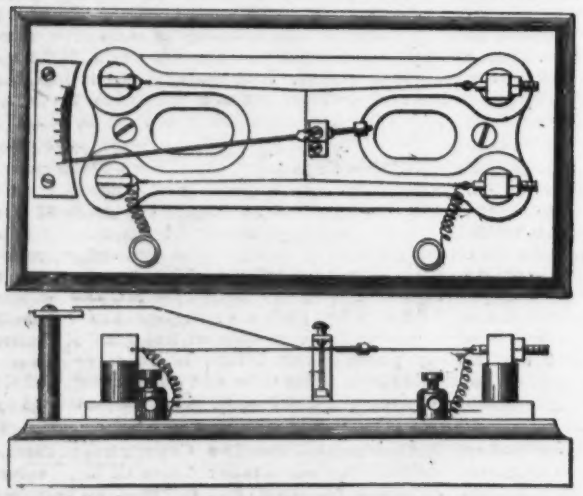
U. S. PATENTS ISSUED JUNE 9, 1891.

453,618. Electric Cigar-Lighter; Harrison B. Brown, of Washington, D. C., Assignor of one-half to William W. Dudley and Frank L. Browne, both of the same place. Application filed Dec. 5, 1890. An electrical incandescent igniting device, consisting of a non-conducting handle, circuit wires leading from a battery and attached to said handle, wherein one of them is divided and its uninsulated ends separated and juxtaposed, a contact maker for temporarily establishing an electrical connection between such juxtaposed ends, and incandescing bridge-wire which joins the uninsulated terminals of circuit-wires and completes the external loop and a substance applied to such bridge wire and which is capable of absorbing or holding an inflammable liquid.

453,633. Electric Switch; Lawrence F. Furlong and Frederick O. Tucker, of Hartford, Conn.; said Furlong assignor to Amos Whitney and Seth W. Bishop, both of the same place. Application filed Oct. 24, 1890. In an electrical switch, a base bearing stationary and movable contacts, and a movable cap bearing blocks adapted to separate the contacts.

453,681. Electrical Measuring Instrument; Frank C. Wagner, of Ann Arbor, Mich. Application filed Dec. 23, 1890. In an electrical measuring instrument, the combination of two substantially similar and equal wires fixed at their extremities and mechanically connected transversely, so as to act in opposition to each other, with means for measuring the movement of said wires when only one of them is traversed by an electrical current. (See illustration.)

453,692. Electric Arc Lamp; Josiah W. Ells, of Pittsburgh, Pa., Assignor of three-fourths to Henry B. Smithson and Louis Kramer, of same place, and William S. Bostwick, of Allegheny, Pa. Application filed March 21, 1890. In an electric arc lamp the combination of an electromagnet, a lever pivoted to a bearing insulated from but connecting it to the lamp frame, a shorter lever or clutch underneath and connected to the first lever by means of a link, a movable vertical rod that extends through a hole in the clutch, a hanger attached directly to the lower end of the vertical rod, a transverse shaft in said hanger, a carbon disc supported in the hanger by the transverse shaft, a ratchet wheel rigidly secured to said shaft, a lever pivoted to the same, a pawl connected and



No. 453,681.—ELECTRICAL MEASURING INSTRUMENT.

adapted to move with said lever and engage the ratchet wheel to rotate the carbon disc, and an insulated link connecting the long end of the pawl lever to the frame of the lamp, whereby the carbon disk is adjusted vertically and partially revolved at the same time by the action of the electromagnet.

453,695. Secondary Battery; William Woodnut Griscom, of Haverford College, Pa. Application filed Dec. 10, 1887. In secondary batteries, an element-containing receptacle and electrical connections extending thereinto, said receptacle being closed, whereby the gases produced by over-charging may be retained therein.

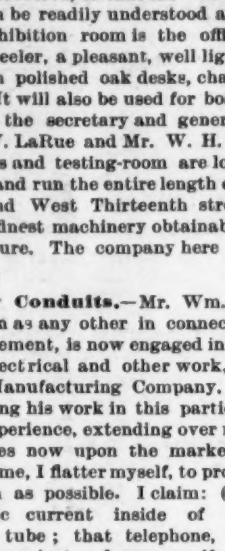
453,696. Engine-Indicator for Steam-Vessels; Wm. E. Hadlock, of Wenham, Mass. Application filed Nov. 14, 1889. The combination, with a steam-engine, of an indicating instrument comprising an electromagnet, a circuit closer in circuit with said magnet, and a projection on the valve-stem of said engine for operating the circuit closer.

453,710. Electric Railway; John Jones, of New York. Application filed Jan. 15, 1891. This invention consists in a crossing-bridge for electric-railway trolleys, having one of its trolley tracks pivoted to the frame thereof, whereby gravity will maintain it in its normal position.

453,722. Attachment for Telephones; Edward E. Baker, of Pittsburgh, Pa. Application filed Feb. 17, 1891. The invention consists in an adjustable device adapted to be secured to the box of a telephone for the purpose of holding a writing tablet or pad for recording messages.

453,723. Electric Fire-Alarm; Michael M. Braun, of Allegheny, Pa. Application filed Feb. 17, 1891. The invention consists in a spring-contact electrically connected to a battery, and an inflammable cord for holding the said spring away from a stationary contact secured in the frame, and a means for attaching the cord together in such a manner that a certain temperature will separate the same.

453,733. Electric Conduit; John E. Price, of Denver, Colo. Application filed Jan. 7, 1891. An electric conduit, comprising a body having longitudinal grooves in its lower face, upwardly



No. 453,742.—MANUFACTURE OF INCANDESCENT ELECTRIC LAMPS.

projecting side-walls and intermediate partitions rising from said body, and downwardly curved side flanges projecting from said body and flush with the lower face thereof, and a lid provided with similar grooves and flanges.

453,742. Manufacture of Incandescent Electric Lamps; Reginald A. Fessenden, of Roseville, N. J. Application filed Feb. 18, 1891. The process of sealing oxidizable leading-in conductors into incandescent electric lamps, which consists of exhausting the air from the bulb and then fusing the glass to the oxidizable conductors. (See illustration.)

453,822. Commutator; Elmer A. Sperry, of Chicago, Ill. Application filed Feb. 20, 1891. A commutator for a dynamo or motor, containing an elastic medium to relieve the insulation from compression strains due to the expansion or contraction of the parts. (See illustration.)

453,858. Commutator for Dynamo-Electric Generators and Motors; Henry Davis and Arthur Henry Stokes, of Derby, England. Application filed Dec. 11, 1890. The combination of a commutator shaft, a commutator cylinder supported thereon, a sleeve on said shaft within said cylinder, brushes supported on said sleeve and bearing against the inner surface of the commutator cylinder, an arm projecting from said sleeve outside said cylinder, and a bracket engaged by said arm.

453,863. Distributing Frame for Electric Conductors; Angus S. Hibbard, of Morristown, N. J., Assignor to the American Telephone and Telegraph Company, of New York. Application filed Feb. 28, 1891. A distributing frame interposed between the cable heads and the switchboard, provided with terminal connections on one side for the line conductors and with similar terminal connections on the other side for the switchboard conductors, and with vertical and horizontal channels in the interior of said frame, through which intermediate conductors uniting the line and switch board connections can be readily drawn in or out without disarrangement of any others.

453,871. Lighting of Tables and the Like by Electricity; Oscar Henry Stovell, of Hampstead, England. Application filed Feb. 24, 1891. A table having channels in the top and legs of same, electric conductors carried in said channels, bolts in the legs connected to said conductors for making contact with sockets connected to the electric house mains, and blocks placed in the circuits and provided with means for receiving candelabra or lamp fittings.

453,888. Electric Switch; Willis Mitchell, of Malden, Assignor of three-fourths to Edward Jewell, of Boston, and Levi L. Parsons and Arthur B. Smith, of Saugus, Mass. Application filed Jan. 8, 1891. In an electric switch, the combination of a movable circuit closing bridge with hollow tapering extinguishers thereon and mechanism for directing the ends of said bridge obliquely forward and downward when contact is broken.

453,898. Electric Battery; Jacob O. Brinkerhoff, of Hackensack, and Milton E. Smith, of Rutherford, N. J. Application filed Nov. 26, 1890. The invention consists of an exciting fluid formed of antimonious chloride and an alkaline chloride.

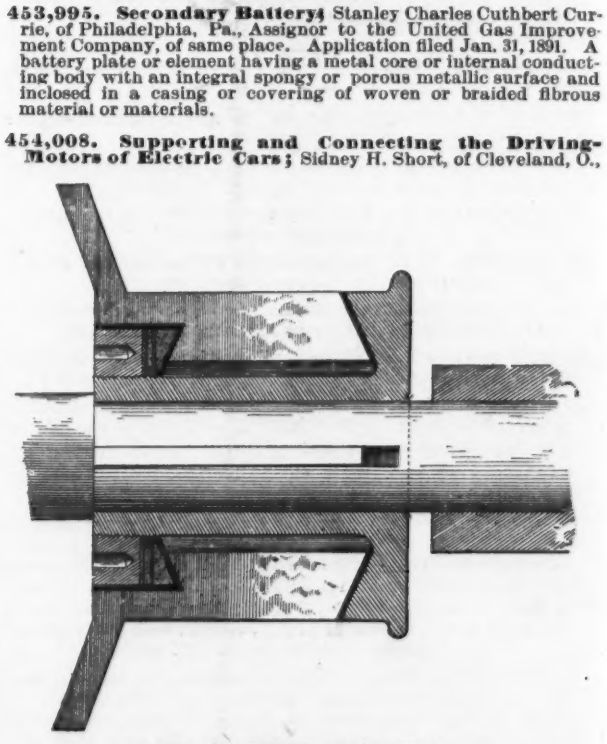
453,950. Secondary-Battery Element; John H. Walter, of Washington, D. C. Application filed Aug. 19, 1890. In a battery element, a transversely corrugated metal tape wound or bent upon itself in such manner as to present its edges outermost.

453,982. Fire-Alarm Telegraph; Geo. F. Milliken, of Boston, Mass., Assignor to the Gamewell Auxiliary Fire Alarm Company, of same place. Application filed Feb. 24, 1891. In a fire-alarm system, the combination, with a circuit including street boxes having manually operated signal sending mechanism and signal receiving mechanism at a main or central office, of an auxiliary circuit or circuits connecting the said street boxes with one or more stations, including in the said box or boxes an independent electromechanical trip or releasing device, and means for automatically restoring the same after each releasement operated by the motor of the street box, with signal sending apparatus at the said station or stations.

453,993. Non-Interference Signal-Box; Fred. W. Cole, of Newton, Mass., Assignor of one-half to Moses G. Crane, of same place. Application filed Feb. 7, 1891. In a non-interference signal-box, a signaling train, a non-interference magnet and its armature, and a locking lever for moving the locking lever, a retarding or timing device for said signaling lever, and a box controller governed by said armature.

453,995. Secondary Battery; Stanley Charles Cuthbert Currie, of Philadelphia, Pa., Assignor to the United Gas Improvement Company, of same place. Application filed Jan. 31, 1891. A battery plate or element having a metal core or internal conducting body with an integral spongy or porous metallic surface and inclosed in a casing or covering of woven or braided fibrous material or materials.

454,008. Supporting and Connecting the Driving-Motors of Electric Cars; Sidney H. Short, of Cleveland, O.,



No. 453,822.—COMMUTATOR.

Assignor to the Short Electric Railway Company, of same place. Application filed Nov. 22, 1893. The invention consists of a car and one or more propelling motors, comprising each an armature mounted on and connected directly with a driving axle and non-rotative field magnets, also a frame pendulously hung from the car axles and having the said field magnets mounted thereon.

454,016. Metallic Circuit Test and Time Signal for Telephone Exchanges; Joseph J. O'Connell, of Chicago, Ill., Assignor to the Western Electric Company, of same place. Application filed Oct. 4, 1888. The combination, with the individual annunciator of a metallic multiple switchboard telephone line circuit, of an extra winding on the core of said annunciator, said extra winding being in a circuit, including a battery and rheotome, a telephone included in a ground circuit having a terminal adapted to be closed to a test piece of the telephone circuit, and a ground connection for the telephone line circuit at the subscriber's station thereon, whereby on closing the terminal of the ground circuit containing a telephone to the terminal of the line, the operator listening at the telephone in said ground circuit may hear the hum caused by the vibratory current induced upon the line.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.